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PERSONALITY CHARACTERISTICS OF JUVENILE DELINQUENTS
I. A METHOD FOR THE SELECTION OF DIFFERENTIATING TRAITS

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INTRODUCTION

Scientifically controlled studies have revealed a number of differential factors in the personality of juvenile delinquents. While it is too early to assume that certain factors are peculiarly distinctive, it is evident that on a comparative basis delinquents manifest characteristics which distinguish them from the socially adjusted. Bryant (2) has called attention to a reliable difference between delinquents and non-delinquents in "will-temperament." Bridges and Bridges (1), by means of the Pressey X-O technique, found that delinquent boys as a group consider fewer things wrong but have more worries than normal boys. This conclusion is supported by Courthial (3) in an investigation of delinquent girls. Slawson (5) and Courthial (3) have discovered striking differences in emotional stability between delinquents and non-delinquents. According to these investigators, both boy and girl delinquents exhibit a greater number of neurotic traits than do control groups. Smith (6) has pointed out that delinquents display more of a tendency toward feelings of inferiority than non-delinquents.

Constitutionally then it appears that the personality of delinquents differs in several interesting and significant respects from the personality of normally adjusted individuals. Further exploring, however, may well be done. Stated generally, the purpose of the present study is an attempt to answer in a limited manner the question: Are there qualities or traits which are definitely related to the personality of juvenile delinquents?

PROBLEM AND METHOD

A technique devised by Pressey (4), the Interest-Attitude Tests, was used as a basis for the succeeding analysis. This instrument consists of four parts or tests, each containing 90 items. The subject is instructed to respond discriminatingly to words suggesting things considered wrong (Test I); anxieties, fears, or worries (Test II); likes and interests (Test III); and kinds of people liked or admired (Test IV). Norms are available for the separate tests by sex and grade (sixth grade to fourth year college) in terms of number of responses to each item per 100 cases, hereinafter designated times-in-100.[2]

Employing the Pressey norms for comparative purposes, an effort was made to ascertain those items from each test which, in varying degrees, differentiated delinquents from non-delinquents. This involved an analysis of the frequency

[1] From Ohio State University.

[2] From Test I the first five items are accidents, fighting, ignorance, talking back, and crying. The subject is instructed to indicate by a cross (X) everything which is regarded as wrong, and by a double cross (XX) everything considered very wrong. Thus if a given item were single-crossed by 35 and double-crossed by 20 subjects out of a group of 60, the total number of responses would be 75 and the number of responses per 100 cases would be 125.

with which responses to each item were made by the delinquent group and reduction of resulting frequencies to times-in-100. Essentially speaking, the problem was one of finding, on the basis of comparative frequency with which delinquents and non-delinquents respond to the various items, those responses which most clearly typify juvenile delinquents.

For the investigation the cases of 316 boys from an institution for juvenile delinquents were available. All subjects were of the white race. Life ages ranged from 14 years, 0 months to 17 years, 11 months. No other forms of selection were attempted. The group constituted apparently a fairly representative sample of delinquent boys in general.

Since item norms for the Interest-Attitude Tests are stated in terms of grade level, the 316 delinquent cases were subdivided into four groups according to life age for purposes of comparing the responses of delinquents with norms for non-delinquents approximately age for age. It was assumed that the median life ages for grades 8, 9, 10, and 11 were equivalent to the conventional age-grade standards, i.e., 14, 15, 16, and 17 years of age, respectively. In fact Pressey found the median life ages of boys on whom norms were established to be 13.9, 15.0, 16.0, and 16.8 for the grades in question. Hence, the experimental group (delinquents) were subdivided similarly as follows: 66 cases in the 14-year group; 75 cases in the 15-year group; 112 cases in the 16-year group; and 63 cases in the 17-year group.

Discrepancies between the medians for the foregoing four life age groupings and the median life ages obtained by Pressey for the boys in each of the four grades, 8, 9, 10, and 11 were without significance. [3]

Criteria for selection of differential items were established by a series of steps illustrated from the following tabular arrangement:

TABLE 1

TECHNIQUE OF ITEM ANALYSIS FOR INTEREST-ATTITUDE TESTS

Item No.	Frequency	Times-in-100 (Delinquent)	Times-in-100 (Normal)	Dv.
1	48	73	51	+22
20	46	70	96	-26
39	27	41	36	+ 5
43	72	109	116	- 7
60	65	98	117	-19

Table 1 shows the form of analysis used, illustrated by five items from Test I (things considered wrong). The items, according to numbers entered in the first column, are accidents, bribery, disagreement, pool rooms, and bullying. Illustrative data are based on the 14-year group. The table is interpreted as

[3] Median life ages for each grade on which the Interest-Attitude Tests were standardized are reported for both sexes by S.L. and L.C. Pressey in a manual, including directions for administering the tests, instructions for scoring, and complete norms. Published by The Psychological Corporation, New York, N.Y.

follows: 66 delinquent boys of the 14-year group considered item 1 (accidents) wrong 48 times, which means that 14-year delinquents responded to the item 73 times-in-100. Compared to this the norms indicate that the control group (grade 8, equivalent to 14-year non-delinquent boys) responded to the same item 51 times-in-100. The difference in response is thus 22 times more for delinquents than non-delinquents. This value is recorded in the column headed Dv., meaning deviation. When times-in-100 was greater for delinquents than non-delinquents the deviation for the particular item was given a plus sign. When the converse was true the deviation was identified by a minus sign. An inspection of deviations in Table 1 reveals that in the case of items 1 and 39 delinquents responded proportionately a greater number of times than the control group; to items 20, 43, and 60, non-delinquents exceeded the experimental group as to times-in-100. Computations similar to those shown in Table 1 were made for the 90 items comprising each of the four tests. Each age group was treated separately for each test. Thus, there were four arrays of deviations for Test I; four for Test II; and the same number each for Tests III and IV.

As a further step in the development of criteria four ogives were constructed, one for each test, based on the total number of deviations for the four age groups, each ogive incorporating 360 deviations. On each ogive the 75th percentile point, for the particular array of deviations in question, was located. Since the purpose of the plus and minus signs was to indicate direction of deviations these denotations were disregarded in constructing the ogives. Thus, the first criterion for selecting differential items was ascertained, namely, to be regarded as basically significant the magnitude of deviation of an item must equal or exceed the value for the 75th percentile of the array of deviations in question.[4] To illustrate: the 75th percentile for 360 deviations based on the results of Test I is 19. In Table 1 is an array of five sample deviations from Test I, 14-year group. Applying the criterion heretofore expressed, items 1, 20, and 60 are fundamentally significant because each equals or exceeds 19.

Following the same procedure, differential items were selected from each of the four arrays of deviations, i.e., by life age groups, for each of the four tests. The value for the 75th percentile in terms of 360 deviations in Test II was found to be 25; for Test III 31; and for Test IV 29.

Application of the first criterion led logically to a second criterion. As the deviations for each age group in relation to each given test were analyzed for differential items, it became evident that there was considerable variability both in the type of item which was significant from age to age and consistency with which certain items were differential from one age group to another. Hence, a second criterion developed: in proportion to whether or not an item was differential for one, two, three, or four age levels it was considered as more or

[4] Some question may be raised as to the reason for adopting the 75th percentile point in each series of deviations as the value which the deviation of each item must equal or exceed in order to be regarded as differential. In establishing such a point the investigator was faced with two possibilities. First, an entirely arbitrary value could have been selected. Second, a value could be found which was an expression of the quantitative tendencies of the data themselves. The latter procedure was employed and the value of the 75th percentile set as the point of origin. It was assumed that so far as the operation of this one criterion is concerned items would become more and more sensitive in differentiating control and experimental groups in proportion as the value-point was moved away from modal deviations.

less significant.

Growing out of the first and second criteria was a third criterion on the basis of which to judge the effectiveness of an item in differentiating between delinquents and non-delinquents. This third standard may be illustrated as follows: from Table 1 it will be noted that item 1 exceeds the 75th percentile of 19 by 3 points; item 20 by 7; and item 60 is exactly at 0. Items 39 and 43 are not regarded as differential, each being less than the 75th percentile with which it is compared. It would appear, therefore, that item 20 is the most significant of the five items listed. Conventionally stated, therefore, the third criterion is: an item is more or less effective in proportion to the magnitude of its difference from the value of the 75th percentile.

The last principle has been applied along with the two criteria previously described. The operation of the three criteria in selection of differential items will be more thoroughly clarified in the subsequent analysis.

STATISTICAL ANALYSIS

Employing the three criteria, Table 2 was constructed, showing differential items from Test I according to age level.

TABLE 2

DIFFERENTIAL ITEMS BY AGE GROUP FROM TEST I (THINGS CONSIDERED WRONG), BASED ON THREE CRITERIA *

14-year group

accidents	+ 3,I	poker	- 1,I	outcast	+ 2,III
atheist	0,IV	tobacco	-23,I	bullying	0,IV
having a temper	- 1,I	being conceited	-20,IV	playing cards	+ 4,IV
smoking	-15,I	spitting	-21,II	playing hookey	- 4,I
bribery	- 7,IV	betting	-23,I	being a snob	- 4,II
being a cad	- 3,II	gang	+26,IV	yellowness	- 3,I

15-year group

atheist	0,IV	petting	0,I	noisiness	+10,I
pawning jewelry	0,I	being conceited	-13,IV	bullying	- 7,IV
carrying a revolver	+21,III	spitting	- 1,II	playing cards	+ 5,IV
insanity	+ 4,II	gang	+24,IV	punishment	0,I
anger	+19,III	prison	+ 3,III	shouting	+ 2,II
bribery	-32,IV	outcast	+ 6,III	lawlessness	- 7,II

16-year group

speeding	+ 3,II	anger	+ 7,III	gang	+27,IV
atheist	- 7,IV	bribery	-15,IV	prison	+13,III
carrying a revolver	+48,III	arguing	+ 6,II	bullying	- 6,IV
teasing someone	+ 1,II	freak	+ 4,II	playing cards	+17,IV
insanity	+ 3,II	being conceited	-32,IV	using slang	+ 2,II

*In Tables 2 to 9 the Arabic notation after an item indicates the magnitude of difference between the deviation of the item in question and the 75th percentile; a positive or negative sign shows direction of the original deviation; the Roman notation signifies the number of age levels with respect to which a given item equals or exceeds the 75th percentile.

TABLE 2 - Continued

17-year group

fighting	+18,I	arguing	+37,II	divorce	+ 9,I
speeding	+ 8,II	being a cad	0,II	playing hookey	+13,I
atheist	- 7,IV	freak	+ 4,II	suspicion	+ 9,I
carrying a revolver	+63,III	being conceited	-39,IV	sickness	+12,I
		gang	+51,IV	shouting	0,II
teasing someone	+ 6,II	prison	+14,III	using slang	+ 5,II
smoking	+ 2,I	outcast	+ 5,III	lawlessness	-18,II
anger	+ 5,III	toughness	0,I	war	+ 1,I
bribery	-10,IV	bullying	- 2,IV	being a snob	-23,II
peddling	+ 8,I	playing cards	+34,IV		

Table 2 is interpreted as follows: atheist listed in the items of the 14-year group has an Arabic notation of 0, meaning that its deviation was exactly 19 for the 14-year age level. The Roman notation IV shows that the deviation for this paticular item equalled or exceeded the 75-percentile likewise for the 15, 16, and 17-year groups. By contrast, the item tobacco, although its deviation exceeded the 75-percentile by 23, is found to be differential only at the 14-year level (see Roman notation).

The three criteria were applied to test II. Differential items were ascertained for each age level. These are set forth in Table 3.

TABLE 3

DIFFERENTIAL ITEMS BY AGE GROUP FROM TEST II (WORRIES, FEARS, ANXIETIES), BASED ON THREE CRITERIA

14-year group

suffering	+ 9,III	death	+16,IV	ache	0,I
collision	- 2,I	storms	+ 1,I	disease	+ 5,I
poison	+ 5,III	burglars	+ 1,I	flames	+ 2,I
choking	+ 1,II	gun	+15,II	thieves	+ 3,I
pain	0,IV	floods	+ 8,I	dying	+ 9,IV
hold-ups	0,II	homeliness	0,II	falling	0,I
knives	+ 5,I	family	+ 8,IV	funeral	+18,IV
rackets	+ 8,I	danger	+ 6,III	robbers	+ 9,II
grave	+ 1,III	jail	+13,IV	sickness	+ 7,II
suffocating	+ 3,I	sins	+15,IV	operation	+ 6,II
tuberculosis	+ 5,II			wrecks	+14,III

15-year group

suffering	+ 5,III	death	+15,IV	dreams	0,I
detective	+ 7,II	crimes	+ 1,II	sins	+ 7,IV
murder	+10,III	being hurt	+ 7,I	dying	+23,IV
poison	+12,III	being unlucky	+ 9,I	funeral	+ 2,IV
fainting	+ 6,I	homeliness	+10,II	sickness	+ 8,II
smothering	0,I	family	+37,IV	operation	+ 4,II
pain	+ 7,IV	craziness	+ 3,I	wrecks	+ 4,III
grave	+ 8,III	jail	+17,IV	work	+ 3,I

16-year group

suffering	+15,III	tuberculosis	0,II	jail	+25,IV
murder	+11,III	death	+21,IV	sins	+16,IV
poison	+ 2,III	family	+13,IV	dying	+18,IV
pain	+ 1,IV	danger	0,III	funeral	0,IV
grave	+ 8,III			wrecks	+ 1,III

TABLE 3 - Continued

17-year group

detective	+11,II	enemies	+ 3,I	jail	+30,IV
murder	+ 9,III	death	+22,IV	sins	+ 7,IV
cheating	+ 4,I	crimes	+ 7,II	smoking	+ 2,I
choking	+ 3,II	examinations	-15,I	dying	+ 8,IV
pain	+11,IV	gun	+ 5,II	funeral	+ 6,IV
hold-ups	+ 6,II	family	+24,IV	robbers	+ 4,II
		danger	+ 1,III		

Table 3 is interpreted in a similar manner to Table 2. It is obvious from an inspection of the table that items are significant for a varying number of age levels. For example, as revealed by Roman notations, rackets occurs only at the 14-year level; hold-ups occurs in two age groups, 14-year and 17-year; grave appears in the 14, 15, and 16-year groups; and death is found in all age groups from 14-year to 17-year.

Based on criteria described heretofore Table 4 shows differential items by age groupings from Test III.

TABLE 4

DIFFERENTIAL ITEMS BY AGE GROUP FROM TEST III (LIKES AND INTERESTS), BASED ON THREE CRITERIA

14-year group

drawing	+ 6,I	animal trainer	+25,II	history stories	+21,I
movie star	+34,IV	doctors	0,I	picture puzzles	+12,I
soldiers	+17,I	auto driving	+ 3,II	parties	+ 3,II
actors	+ 5,I	sailors	+20,II	story writing	+ 5,I
clubs	+16,II	exploring	+ 1,I	tap dancing	+ 6,III
magazines	+22,II	locomotive engineer	+ 2,I	Red Cross work	+16,II
joyriding	+15,III	art galleries	+ 2,I	candy	+29,II
soda clerk	+ 6,II	church	+23,IV	swinging	+13,II
rancher	0,I	reading	+12,I	geography games	+14,I
circus	+34,IV	children	+ 5,I	mountains	+ 5,I
bicycling	+14,I	studying	+16,I	whistling	+ 1,I
		coffee	+21,III		

15-year group

movie star	+25,IV	circus	+28,IV	cards	+ 6,II
comedies	+ 2,I	animal trainer	+ 4,II	cowboy	+13,II
clothes	+10,II	card parties	+10,I	parties	+15,II
beaches	+ 9,I	auto driving	+18,II	tap dancing	+20,III
clubs	0,II	chewing gum	+ 8,I	Red Cross work	+ 4,II
magazines	+ 2,II	prizes	+ 4,I	candy	+26,II
joyriding	+21,III	church	+23,IV	swinging	+ 2,II
ice-cream man	+ 9,I	fancy dancing	+ 6,III	acrobats	+ 4,II
soda clerk	+ 1,II			shooting	+11,I

16-year group

movie star	+ 9,IV	hunting	+ 5,II	cards	+ 4,II
joyriding	+ 4,III	church	+13,IV	cowboy	+12,II
circus	+ 9,IV	fancy dancing	+ 7,III	tap dancing	+ 6,III
poker	+ 6,I	coffee	+ 8,III	acrobats	0,II

17-year group

movie star	+ 3,IV	baseball	+14,I	baseball players	+22,I
clothes	+10,II	sailors	+ 2,II	church	+13,IV
college	- 5,I	hunting	+17,II	fancy dancing	0,III
circus	+ 2,IV			coffee	+ 4,III

Interpreted in the same way as Tables 2 and 3 items from Test III, as listed in Table 4, are seen to vary in differential significance from one to four age levels. For instance, of the likes and interests, movie star is present at all age levels, whereas doctors occurs only in one age group.

Analysis of Test IV resulted in the differential items listed in Table 5, shown according to age group.

TABLE 5

DIFFERENTIAL ITEMS BY AGE GROUP FROM TEST IV (KINDS OF PEOPLE LIKED OR ADMIRED), BASED ON THREE CRITERIA

14-year group

alert	-11,III	quick	+ 4,IV	busy	+ 5,I
cooperative	-14,IV	wealthy	+14,IV	joyful	+ 2,III
reliable	-10,II	well-dressed	+ 9,III	quiet	+ 5,III
capable	-10,I	loving	+24,I	sharp	0,II
lovely	+22,II	careful	+13,II	handsome	+32,IV
husky	+22,III	good-looking	+29,III	gentle	+ 3,II
brave	+ 7,IV	rich	+23,III	hopeful	+13,II
incentive	+ 4,I	up-to-date	+ 5,II	fair	+11,II
		humorous	- 5,III		

15-year group

talented	- 5,II	able	+ 1,I	up-to-date	+ 5,II
cooperative	- 6,IV	quick	+19,IV	joyful	+ 7,III
progressive	- 8,II	wealthy	+19,IV	quiet	+17,III
lovely	+ 4,II	well-dressed	+29,III	sharp	0,II
husky	+13,III	diligent	0,I	handsome	+14,IV
lively	+ 8,II	careful	+ 6,II	gentle	+ 6,II
easy-going	+ 2,I	peppy	+ 5,I	hopeful	+ 4,II
brave	+ 8,IV	good-looking	+17,III	fair	+13.II
		rich	+ 6,III		

16-year group

alert	- 1,III	brave	+ 3,IV	original	- 4,II
cooperative	- 4,IV	quick	+13,IV	humorous	- 3,III
husky	+23,III	wealthy	+ 2,IV	quiet	0,III
lively	+ 7,II	good-looking	+ 2,III	handsome	+ 8,IV
		rich	+ 6,III		

17-year group

alert	-18,III	broad-minded	-29,I	peaceful	0,I
courageous	- 9,I	sociable	- 3,I	economical	-14,I
talented	- 8,II	brave	+ 6,IV	original	-10,II
cooperative	-15,IV	quick	+ 8,IV	humorous	-20,III
progressive	-11,II	wealthy	+ 4,IV	witty	-16,I
reliable	-15,II	well-dressed	+ 8,III	joyful	+ 1,III
efficient	-11,I	amiable	- 6,I	handsome	+11,IV
having initiative	- 7,I	sincere	-11,I	punctual	- 1,I
optimistic	- 1,I			enthusiastic	- 2,I

As indicated previously certain items in the separate tests are shown to be significant for only one age level, others for two or more age groups. In Test IV the situation is no different, as is clear from Table 5. As a case in point, handsome appears in all age groups; quiet in three; up-to-date in two; and capable in only one.

Tables 2, 3, 4, and 5 provide all of the basic information necessary to a more extended analysis of the Interest-Attitude Tests. The major problem, in the light of the three criteria, consisted in selecting from the four arrays of differential

items those which from each test were of greatest significance in the personality of juvenile delinquents. To do this the following procedure was adopted: items which from any given test appeared in all four age groups were listed separately, together with the extent of difference of each deviation from the 75-percentile; items appearing at three age levels were similarly listed; and likewise items found in two and one age groups. For example, an inspection of Table 2 shows that from Test I atheist is found in age groups 14, 15, 16, and 17 with differences from the 75th percentile of 0, 0, -7, -7, respectively; carrying a revolver appears in three age groups with differences of +21, +48, and +63 from the 75-percentile; speeding is found in two age groups with differences of +3 and +8; and accidents appears at only one age level with a difference from the 75-percentile of +5. In all cases in which an item appeared in two, three, or four age groups its mean difference from the 75th percentile was computed. The mean was employed because it seemed to be that specific value for the particular item which indicates on the average its discriminative significance for the age groups in which it is found.

Table 2 shows that six items were differential for four age levels,[5] atheist -3.5, bribery -16.0, being conceited -26.0, gang +32.0, bullying -3.8, and playing cards +15.0. Four items appear in three age groups, carrying a revolver +44.0, anger +10.3, prison +10.0, and outcast +4.3. Eleven items were differential for two age levels and twenty-one differentiated for only one age group.

It will be recalled that the basic lists of items from each test, shown in Tables 2 to 5, were compiled in terms of the fact that magnitudes of deviations of certain items equalled or exceeded the value of the 75-percentile of the array of deviations in question. The operation of this criterion was fundamental to the application of the other two. As a result of applying the last two criteria it was ascertained that (a) items were significant for varying numbers of age levels from one to four, and (b) individual items, irrespective of the number of age groups in which found, varied as to the extent of their differences from the 75-percentile. Conclusions suggested thus far, therefore, from analysis of items in the basic lists (Tables 2 to 5) are: first, particular items are significant in proportion to the number of age levels in which they occur; and second, particular items are significant in terms of the extent of difference from the 75-percentile.

By the application of successive criteria it was possible to select items which best differentiated juvenile delinquents, and rank such items in the order of their significance. The mean differences from the 75-percentile having been computed for items appearing in two, three, or four age groups, an arbitrary point of origin was fixed which such mean differences must equal or exceed. It was assumed that means must equal or exceed 10 in order to be included among the most differential items. Items which were found in only one age group, but the differences of which from the 75th percentile equalled or exceeded 10, were included in the list of most significant items, their differential value, of course, being limited by the fact of appearing in only one age group. The higher or lower ranking of an item was first of all governed by the number of age groups in

[5] Numbers after each item indicate the mean difference of its deviation from the 75-percentile: signs show the direction of original deviations.

which it appeared, second by its mean difference from the 75th percentile. Items appearing in four age groups were first in order, ranked subsequently in terms of the magnitude of their mean differences. Items appearing in three age groups were next in order with items appearing in two and one age groups following. Hence, if the mean difference of an item was +15 based on appearance in four age groups it was regarded as having greater ranking significance than one with the same or greater mean value based on appearance in three or fewer age groups.

In Tables 6, 7, 8, and 9 are listed items from each of the four Interest-Attitude Tests which have been ascertained as most differential for juvenile delinquents.

TABLE 6

SIGNIFICANT ITEMS FROM TEST I (THINGS CONSIDERED WRONG)

gang	+32,IV	prison	+10,III	betting	-23,I
being conceited	-26,IV	arguing	+22,II	fighting	+18,I
bribery	-16,IV	being a snob	-14,II	smoking	-15,I
playing cards	+15,IV	lawlessness	-13,II	playing hookey	+13,I
carrying a		spitting	-11,II	slickness	+12,I
revolver	+44,III	tobacco	-23,I	noisiness	+10,I
anger	+10,III				

Of 42 separate items from Test I contained in the basic list of Table 2, eighteen or 43 per cent appear to be markedly differential according to assumptions explained in this study. That the importance of items seems to be related somewhat to the number of age groups in which they are found is suggested by the following:

of 6 items in 4 age groups, 4 are significant = 67 per cent;
of 4 items in 3 age groups, 3 are significant = 75 per cent;
of 11 items in 2 age groups 4 are significant = 36 per cent;
and of 21 items in 1 age group 7 are significant = 33 per cent.

TABLE 7

SIGNIFICANT ITEMS FROM TEST II (WORRIES, FEARS, ANXIETIES)

jail	+21,IV	dying	+15,IV	suffering	+10,III
family	+21,IV	sins	+11,IV	gun	+10,II
death	+19,IV	murder	+10,III	examinations	-15,I

From Test II 46 separate items are listed in Table 3, of which 9 or 20 per cent are significant. The relationship between number of age levels in which items appear and their significance again appears to be substantiated by the following:

of 7 items in 4 age levels, 5 are significant = 71 per cent;
of 6 items in 3 age levels, 2 are significant = 33 per cent;
of 10 items in 2 age levels, 1 is significant = 10 per cent;
and of 23 items in 1 age level, 1 is significant = 4 per cent.

TABLE 8

SIGNIFICANT ITEMS FROM TEST III (LIKES AND INTERESTS)

circus	+18,IV	magazines	+12,II	soldiers	+17,I
movie star	+18,IV	sailors	+11,II	studying	+16,I
church	+18,IV	hunting	+11,II	bicycling	+14,I
joyriding	+13,III	auto driving	+11,II	geography games	+14,I
coffee	+11,III	Red Cross work	+10,II	baseball	+14,I
tap dancing	+11,III	clothes	+10,II	picture puzzles	+12,I
candy	+28,II	baseball player	+22,I	reading	+12,I
animal trainer	+15,II	history stories	+21,I	shooting	+11,I
cowboy	+13,II			card parties	+10,I

Table 4 contains 51 basic items from Test III. Table 8 reveals that 26 or 51 per cent of these are significant. The following is of interest in support of relationships already mentioned:

of 3 items in 4 age levels, 3 are significant = 100 per cent;
of 4 items in 3 age levels, 3 are significant = 75 per cent;
of 15 items in 2 age levels, 9 are significant = 60 per cent;
and of 29 items in 1 age level, 11 are significant = 38 per cent.

TABLE 9

SIGNIFICANT ITEMS FROM TEST IV (KINDS OF PEOPLE LIKED OR ADMIRED)

handsome	+16,IV	rich	+12,III	broad-minded	-29,I
quick	+11,IV	alert	+10,III	loving	+24,I
wealthy	+10,IV	lovely	+13,II	witty	-16,I
cooperative	-10,IV	reliable	+13,II	economical	-14,I
husky	+19,III	fair	+12,II	efficient	-11,I
good-looking	+16,III	progressive	-10,II	sincere	-11,I
well-dressed	+15,III	careful	+10,II	capable	-10,I

In Table 9 are listed 21 items, or 46 per cent, ascertained as significant from 46 items contained in Table 5, the basic list from Test IV. The following indicates relationships between number of age levels in which an item appears and its significance:

of 5 items in 4 age levels, 4 are significant = 80 per cent;
of 8 items in 3 age levels, 5 are significant = 62 per cent;
of 12 items in 2 age levels, 5 are significant = 42 per cent;
and of 21 items in 1 age level, 7 are significant = 33 per cent.

CONSISTENCY OF THE DIFFERENTIATING TRAITS

As a means of establishing consistency of the procedures adopted for selecting items most differential for juvenile delinquents, a further form of analysis was undertaken. It may be described as follows: first, the mean times-in-100 response was made to each item by control subjects from grades 8, 9, 10, and 11 was computed; second, the frequency with which all four age groups of delinquent boys

responded to each item was ascertained, these values in turn being reduced to times-in-100; third, the same item-by-item comparisons were made in this last instance as has been discussed heretofore. That is, an attempt was made to determine whether or not by treating the control and experimental groups without regard to life age approximately the same items would emerge to distinguish delinquents from non-delinquents as have been found previously. Thus, four series of deviations resulted. The 75-percentile was again ascertained for each series of deviations by means of ogives. From each test the number of items which equalled or exceeded the respective numerical values of the 75-percentile were as follows: [6]

Test I: 14 plus items; 6 minus items;
Test II: 21 plus items; 0 minus items;
Test III: 20 plus items; 0 minus items;
Test IV: 15 plus items; 6 minus items.

Items selected as being most significant were those exceeding the 75th percentile by ten or more points.

Table 10 shows for each test, in terms of a comparison of the total control and experimental groups, items which exceed by 10 or more points the 75-percentile of the array of deviations in question. As in previous connections plus and minus signs denote the direction of deviations.

In comparing the total control and experimental groups the greater or less effectiveness of an item in differentiating delinquents from non-delinquents was judged finally by the amount of its excess over the value of the 75th percentile involved. By this method it was possible to assign a crude ranking to the items selected. As shown in Table 10, when total groups were compared, seven items from Test I emerged that were ten or more points above the value of the 75th percentile. These are shown in rank order in the column headed Rank A. The item carrying a revolver exceeded the 75-percentile by 36 points and so is assigned first ranking in the A series. Other selections and rankings of items were made in an identical manner.

The problem of selecting a final list of items that best differentiate between delinquent and non-delinquent subjects is embodied in the question: To what extent are the most significant items selected according to the first set of assumptions, i.e., the three criteria described earlier in this study related to those items ascertained by the last method of analysis? A simple device was employed for determining the relationship. A glance at Table 6 will reveal that the seven most significant items in rank order from Test I, selected by the three criteria, are gang, being conceited, bribery, playing cards, carrying a revolver, anger, and prison. That is, gang is ranked 1, being conceited 2, and so on to prison, receiving a rank of 7. For comparative purposes the column headed Rank B is used in Table 10 to show the foregoing rankings. Thus, carrying a revolver is ranked 1 in the A series and 5 in the B series; gang is ranked 2 in the A series and 1 in the B series; and similarly for the other items. A discrepancy should be

[6] Values of the 75-percentile for each of the four latter series of deviations are: Test I, 15; Test II, 22; Test III, 29; Test IV, 27.

TABLE 10

SIGNIFICANT ITEMS IN TERMS OF TOTAL GROUPS

Item	Excess over 75 percentile	Rank A	Rank B
	Test I (things considered wrong)		
carrying a revolver	+36	1	5
gang	+35	2	1
being conceited	-31	3	2
being a snob	-22	4	9
playing cards	+18	5	4
bribery	-17	6	3
prison	+11	7	7
	Test II (worries, fears, anxieties)		
jail	+24	1	1
family	+23	2	2
death	+20	3	3
dying	+17	4	4
sins	+15	5	5
	Test III (likes and interests)		
church	+24	1	3
circus	+19	2	1
movie star	+18	3	2
tap dancing	+11	4	6
joyriding	+10	5	4
candy	+10	6	7
	Test IV (kinds of people liked or admired)		
handsome	+17	1	1
husky	+17	2	5
quick	+12	3	2
well-dressed	+12	4	7
wealthy	+11	5	3
good-looking	+11	6	6
cooperative	-11	7	4
rich	+10	8	8

noted: being a snob does not appear among the first seven items in Table 6, but is ninth in rank. It has been so indicated in the B series of Table 10. Further anger appears as the sixth ranking item in Table 6 but is not among the seven from Test I in Table 10. Aside from these exceptions the highest ranking items from Test I as set forth in Table 6 are identical with those listed in Table 10. The same comparisons were drawn for Tests II, III, and IV, employing Tables 7, 8, and 9, respectively, for assigning ranks in series B of Table 10. In only one other instance was there lack of identity between the A and B series of items in Table 10. Table 8 shows that coffee is the fifth ranking item from Test III. This item does not appear among the six items from this test listed in Table 10. The item candy is ranked 7 in Table 8, this being the placement assigned in the B series of Table 10.

As a means of comparing the A and B series of Table 10 the term mean displacement has been utilized. This device shows merely how closely the rank order of items in one series follows the rank order of the other. If the differences in

ranks for items from Test I are computed and these averaged, the mean displacement is found to be 2.1; for items from Test II the mean displacement is 0; for items from Test III, 1.3; and Test IV, 1.5. With only minor exceptions it appears that the items listed in Table 10 from the four Interest-Attitude Tests are the most sensitive in differentiating between delinquents and non-delinquents. This fact is established by two dissimilar methods of analysis. The method of selecting items by three criteria is likely the more adequate of the two because it introduces a greater degree of statistical refinement. It is interesting to note, however, that irrespective of the method of selection the items found to be most differential are markedly similar.

DISCUSSION AND SUMMARY

While in this investigation chief emphasis has been placed on methodology, a not unimportant query might well be raised as to what fundamental dispositions are revealed in the personality of juvenile offenders by items which effectively differentiate them from normally adjusted individuals. If not only the items of Table 10 but direction which certain responses have taken are interpreted broadly a few generalizations appear to be warranted. First, of things considered wrong undesirable social traits, such as being conceited and being a snob are of negative concern to juvenile delinquents. Second, a pronounced morbid strain seems to characterize delinquents as indicated by their positive emphasis on items of worry or anxiety, such as death, dying, and sins. Third, likes and interests of juvenile offenders are mostly of a superficial or relatively evanescent nature as shown by their pronounced stressing of circus, movie star, tap dancing, joy riding, and candy. Fourth, reactions to kinds of people admired suggest the essentially egocentric character of juvenile delinquents. Items, such as handsome, husky, well-dressed, wealthy, good-looking, and others of a similar sort, are positively viewed while, interesting to note, cooperative receives negative emphasis. The foregoing interpretation gives an imperfect picture of the personality of juvenile delinquents. A more incisive clinical analysis based at least in part on the items of Table 10 would undoubtedly enlarge present understanding of the personality of juvenile offenders.

The most important aspects of this investigation of personality characteristics of juvenile offenders may be summarized briefly. A method has been proposed by means of which items from the Pressey Interest-Attitude Tests may be selected that are differential for delinquent as compared with non-delinquent subjects. The fundamental principal employed implies the operation of three criteria for selecting significant items. Consistency of the basic method is checked by employing a second dissimilar procedure.

By applying successive criteria three facts were ascertained: (a) basic lists of items from each test that are significant; (b) items that are differential for four, three, two, and one age groups; and (c) items which are maximally effective in differentiating delinquents from non-delinquents. It is clear that juvenile offenders differ from non-offenders rather generally in characteristics, such as things considered wrong; worries, fears, and anxieties; likes and interests; and kinds of people liked or admired. More important still is the fact that within these categories certain items are unusually sensitive in showing differences in

the groups studied. If cues provided as a result of the present analysis are indicative, the conclusion is inescapable that delinquents are constitutionally different from normally adjusted individuals.

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DEFICIENCIES IN AMPLITUDE OF JOINT MOVEMENT ASSOCIATED WITH MENTAL DEFICIENCY [1]

A. DOUGLAS GLANVILLE AND GEORGE KREEZER

I. INTRODUCTION

There is considerable evidence that the deficiencies of the mentally deficient are not limited to psychological functions alone, but may extend to other bodily functions and properties.[2] (1,4,8,9). This fact suggests the need for investigations of the covariation that may occur between different traits of the mentally deficient in order to provide clues to the common factors which may underly retardations in development of different characteristics. Investigation of motor development in the mentally deficient should be of particular interest since the motor functions, like the psychological ones, depend on the operation of the nervous system, and so may be expected to provide indications of conditions in this system.

The present study is part of a more extensive investigation being made of the development of motor functions in the mentally deficient (5,6). It is concerned with one particular property of motor activities, namely, the amplitude of movements possible at the various joints of the body. Our problem specifically, was to compare the maximum amplitudes of voluntary and passive joint-movements in sample groups of mentally deficient and of mentally normal subjects.

Limitations in motor activity are quite commonly observed by those working with the mentally deficient. These limitations may show themselves in an increased awkwardness and a lesser freedom of movement, even though these may not be severe enough to justify inferences as to specific neurological lesions. Tredgold, for example, states, "In a considerable number of aments, movement is deficient in quantity ..... The condition is most common in the severest grade but it is also seen in the imbecile and feeble-minded." (9, p. 103). This statement is apparently based on casual clinical observation and not on systematic investigation by means of standardized methods. Although investigations have been reported of some aspects of motor activity in the mentally deficient (8), we have not found reports of any previous work on amplitude of joint movement.

Systematic work on the amplitude of joint movement even among mentally normal individuals has not been very extensive. A survey and bibliography of this work has been given in another paper, in which we have dealt with the question of normative standards of joint-movement (3).

II. CONDITIONS OF THE INVESTIGATION

A. Subjects.

[1] From the Department of Research of The Training School at Vineland, New Jersey. We are indebted to Dr. Edgar A. Doll for helpful suggestions.

[2] The multiplicity of symptoms in the case of certain of the special clinical types, such as the mongolian and the cretin, provides striking illustration of this tendency.

The experimental group of the present study consisted of 10 mentally normal and 10 mentally deficient subjects, all male adults, and without indications in their habitual everyday activities of any motor disorder. All subjects were right handed, as determined on the basis of Lauterbach's inventory for the determination of handedness (7).

The mental ages of the mentally deficient subjects ranged from 9.0 to 9.9 years as measured by the Stanford-Binet Scale (1916 revision). Their daily schedules consisted of either a combination of school work and light manual work or light manual work alone. These subjects had all been diagnosed as mentally deficient by the clinical division of the Vineland Laboratory. None of them were of any special clinical type.[3] With respect to etiology, 5 of these subjects were designated as probably hereditary cases, and 5 as of unknown etiology.

Of the mentally normal subjects, 9 were employees of the institution (4 teachers in the school, 3 members of the laboratory staff, and 1 a cottage attendant) and 1 was engaged in private business. Intelligence tests were not given to these subjects: occupational status was considered an adequate indication that they were of average intelligence or greater.

The subjects were so selected that the height and weight levels of the two groups of subjects were about the same. In the mentally normal group the average height was 5 ft. 9 in., with a range from 5 ft. 4 in. to 6 ft. 1 in.; average weight was 143 pounds with a range from 120 to 172 pounds. In the mentally deficient group the average height was 5 ft. 8 in., with a range from 5 ft. 3 in. to 6 ft. 3 in.; the average weight was 143 pounds, with a range from 116 to 174 pounds. The average age of the mentally normal group was 28.2 years, with a range from 20 to 43 years; the average age of the mentally deficient group was 25.5, with a range from 18 to 46 years.

B. Measuring instrument.

Measurements at all joints were made with the same instrument, what we call a plumb-line goniometer. Its operation is based on the relative movement produced between a circular scale, fixed in position relative to the moving member, and a plumb line provided by a pendulum suspended from the center of the scale. If the angular position of the plumb-line on the scale is noted before and after a given joint movement, a measurement is obtained of the angle through which the joint moves. The instrument may be attached to any part of the body and a record thus obtained of amplitude of movement at an adjacent joint. Further details concerning this instrument are given in (3).

C. Procedure.

Twenty-four different movements were measured on each subject for both passive

[3] The statement that the subjects were of no special clinical type means that they failed to show the special symptoms sometimes associated with mental deficiency and commonly used as a basis for the classification of the mentally deficient into various clinical types. Examples of such special clinical types are mongolism, hydrocephalus, microcephalus, the cerebral infantile palsies, and epileptic amentia. For details see Tredgold (9, pp. 204-292).

and voluntary movements, and, except for two head movements, on both left and right sides of the body. The movements measured are specified in Tables 1 and 2. The value taken as the amplitude of a given movement in each subject was the average of three successive measurements.

Except for movements of (1) lateral flexion of head; (2) abduction of humerus; (3) pronation and supination of forearm; (4) flexion, extension, abduction and adduction of hand; and (5) abduction of femur, the measurements were taken with the subject lying in a supine, or in a prone position on a thin mattress placed on a table. For movements numbered (1), (3), and (4), the subject sat up, and for those numbered (2) and (5) the subject lay extended on his side. For measurements of passive movements, the subject was instructed to relax and the examiner applied force at the same point and attempted to use the same maximum force with all subjects. For measurements of voluntary movements, the subject was instructed to exert maximum effort (for example, to bend the arm as far as he could) and to avoid assistive movements or changes of gross bodily position. One examiner, (G1) made all measurements. To minimize possible variations from subject to subject, a standard set of conditions was adopted for each movement, with respect to position of subject, initial position of part moved, place of attachment of the instrument and procedures used to avoid possibly simultaneous movements at adjacent joints. These conditions and other details of procedure are given in a previous paper (3). Subjects were examined only when in good general health and not fatigued by previous activities.

III. RESULTS

Tables 1 and 2 show, for voluntary and passive movement respectively, the arithmetic means of the amplitude of movement at various joints, the differences between the arithmetic means for the mentally normal and mentally deficient groups, and the associated statistics for indicating the significance of the differences.

Examination of the tables shows:

1. For the large majority of both voluntary and passive movements, the amplitude of movement is greater for the mentally normal group than for the mentally deficient group. Thus, in 89% (41 out of 46) of the voluntary movements, and in 93% (43 out of 46) of the passive movements, the average amplitude of movements in the mentally normal group is greater than that in the mentally deficient group.

2. The differences between the mentally normal and mentally deficient groups are statistically significant in terms of a t (ratio of difference to its estimated standard error) equal to or greater than 2.1, in 15 of the voluntary movements (33%), and 17 of the passive movements (36%). These movements are indicated by an asterisk in the table. In all except one of these movements (voluntary right lateral flexion of the head), the amplitude is greater for the mentally normal group. A value of t equal to 2.1 corresponds to a probability of .975 that a difference of the averages greater than zero and of the same sign will be found in future samples.

3. An additional fact that emerges from examination of the original data,

TABLE 1

COMPARISON OF MENTALLY NORMAL AND MENTALLY DEFICIENT GROUPS IN MAXIMUM AMPLITUDE OF VOLUNTARY JOINT MOVEMENTS. (MEASUREMENTS IN ANGULAR DEGREES).

Part Moved	Mov't	Side	Mentally Normal (N) Mean	Mentally Normal (N) S.D. Mean	Mentally Deficient (MD) Mean	Mentally Deficient (MD) S.D. Mean	Diff. of Means (N-MD)	S.D. Diff	t=Diff./S.D. diff.
Head	Vent.Flex.		59.8	11.7	56.0	8.2	+ 3.8	4.5	.85
	Dors.Flex.		61.2	26.8	46.2	18.4	+16.0	10.2	1.47
	Lat.Flex.	*R	39.4	6.0	51.7	10.4	-12.3	3.8	3.23
		L	42.9	7.7	47.6	11.5	- 4.7	4.4	1.06
	Rotat.	R	77.2	16.1	69.1	15.2	+ 8.1	7.0	1.15
		L	79.8	12.8	73.4	13.8	+ 6.4	5.9	1.09
Upper Arm (at shoulder)	Flex. (forw.)	R	179.0	7.2	171.0	10.2	+ 8.0	3.9	2.05
		*L	179.9	6.3	171.0	11.4	+ 8.9	4.1	2.17
	Exten. (backw.)	R	55.2	10.1	54.5	13.3	+ 0.7	5.3	.13
		L	60.0	12.4	53.3	10.6	+ 6.7	5.1	1.31
	Abduct.	R	129.3	11.7	123.8	13.6	+ 5.5	5.7	.96
		L	130.3	11.2	130.3	13.2	0.0		
	Int.Rot.	*R	94.1	22.1	70.6	19.3	+23.5	9.3	2.52
		*L	100.0	16.3	75.1	14.1	+24.9	6.8	3.66
	Ext.Rot.	*R	82.7	10.0	55.5	21.2	+27.2	7.4	3.67
		*L	83.5	16.2	56.7	17.5	+26.8	7.5	3.57
Forearm (at elbow)	Flex.	*R	138.3	8.5	123.2	12.2	+15.1	4.7	3.21
		*L	144.3	8.9	123.7	11.8	+20.5	4.7	4.36
	Pronat.	R	91.1	25.8	82.4	31.4	+ 8.7	12.8	.68
		L	93.0	20.7	79.8	26.5	+14.2	10.6	1.34
	Supinat.	*R	99.4	11.0	69.4	37.0	+30.0	12.2	2.45
		*L	100.6	10.8	68.3	35.0	+32.3	11.5	2.80
Hand (at wrist)	Flex. (palm.)	R	95.0	10.6	93.0	17.2	+ 2.0	6.4	.31
		L	90.0	9.8	87.4	18.4	+ 2.6	6.6	.39
	Exten. (dors.)	R	54.1	15.2	58.3	8.3	- 4.2	5.4	.77
		L	65.7	12.6	58.1	13.0	+ 7.6	5.7	1.33
	Abduct. (rad.fl.)	R	27.1	7.1	25.7	6.6	+ 1.4	3.0	.46
		L	31.1	8.4	32.9	7.8	- 1.8	3.6	.50
	Adduct. (uln.fl.)	R	66.1	8.1	58.4	13.4	+ 7.7	4.9	1.57
		L	66.1	8.8	56.5	12.9	+ 9.6	4.7	2.04
Thigh (at hip)	Flex. (forw.)	R	97.8	17.0	94.5	17.3	+ 3.3	7.6	.43
		*L	105.6	8.3	91.4	13.8	+14.2	5.1	2.78
	Exten. (backw.)	R	48.4	12.9	36.6	16.6	+11.8	6.6	1.78
		L	42.4	9.9	40.0	14.2	+ 2.4	5.4	.44
	Abduct.	R	70.1	17.0	63.2	14.4	+ 6.9	7.0	.98
		L	71.7	14.1	60.5	14.3	+11.2	6.3	1.77
	Int.Rot.	*R	60.6	15.2	45.8	11.0	+14.8	3.9	2.50
		*L	66.3	13.5	44.9	9.3	+21.4	5.2	4.11
	Ext.Rot.	R	37.0	6.6	29.4	10.7	+ 7.6	4.0	1.90
		L	30.4	8.3	25.1	11.1	+ 5.3	4.4	1.18
Lower Leg(at knee)	Flex.	*R	126.6	6.7	95.1	12.2	+31.5	4.3	7.32
		*L	123.7	6.7	96.9	10.0	+26.8	3.8	7.05
Foot (at ankle)	Plant.Flex.	R	28.2	7.4	22.8	12.8	+ 5.4	4.7	1.14
		L	26.2	8.9	21.4	13.7	+ 4.8	5.1	.94
	Dors.Flex.	R	36.8	6.6	28.9	10.6	+ 7.9	3.9	2.01
		L	39.5	8.3	33.4	12.5	+ 6.1	4.7	1.29

TABLE 2

COMPARISON OF MENTALLY NORMAL AND MENTALLY DEFICIENT GROUPS IN MAXIMUM AMPLITUDE OF PASSIVE JOINT MOVEMENTS. (MEASUREMENTS IN ANGULAR DEGREES).

Part Moved	Mov't	Side	Mentally Normal (N) Mean	Mentally Normal (N) S.D. Mean	Mentally Deficient (MD) Mean	Mentally Deficient (MD) S.D. Mean	Diff. of Means (N-MD)	S.D. Diff	t=Diff./S.D. diff.
Head	Vent.Flex.		76.4	9.2	70.1	12.6	+ 6.3	4.9	1.28
	Dors.Flex.	*	77.2	25.1	55.7	18.5	+21.5	9.9	2.17
	Lat.Flex.	R	60.7	8.2	63.7	8.8	- 3.0	3.8	.79
		L	64.8	9.7	61.2	8.3	+ 3.6	4.0	.90
	Rotat.	R	96.6	14.1	90.0	11.2	+ 6.6	5.7	1.15
		L	95.4	11.1	88.6	12.4	+ 6.8	3.2	1.30
Upper Arm (at shoulder)	Flex. (forw.)	R	184.6	6.4	178.3	8.5	+ 6.3	3.3	1.90
		L	185.4	6.2	179.4	8.9	+ 6.0	2.9	2.07
	Exten. (backw.)	R	67.7	11.9	65.4	12.5	+ 2.3	5.5	.41
		L	70.3	10.2	61.3	15.0	+ 9.0	5.7	1.58
	Abduct.	R	136.7	12.4	135.2	6.1	+ 1.5	4.3	.35
		L	137.2	12.1	139.7	9.9	- 2.5	4.8	.52
	Int.Rot.	*R	101.1	22.5	81.2	12.7	+19.9	8.1	2.45
		*L	108.0	14.1	86.0	8.9	+22.0	5.4	4.07
	Ext.Rot.	*R	92.0	7.2	64.8	17.4	+27.2	5.9	4.61
		*L	92.2	13.9	66.0	13.0	+26.2	6.0	4.36
Forearm (at elbow)	Flex.	*R	143.2	7.6	133.1	9.6	+10.1	3.9	2.59
		*L	147.9	7.8	132.9	12.3	+15.0	4.6	3.26
	Pronat.	R	104.9	22.1	95.1	27.1	+ 9.8	11.0	.89
		L	111.2	15.1	97.7	28.6	+13.5	10.7	1.26
	Supinat.	*R	114.3	15.2	82.1	31.5	+32.2	11.0	2.91
		*L	116.0	13.0	84.0	30.8	+32.0	10.6	3.01
Hand (at wrist)	Flex. (palm.)	R	105.6	13.0	101.0	13.2	+ 4.6	5.8	.79
		L	103.3	10.6	105.7	11.4	- 2.4	4.9	.49
	Exten. (dors.)	*R	91.8	13.0	79.6	7.1	+12.2	4.7	2.59
		*L	104.2	19.0	79.8	8.9	+24.4	6.6	3.69
	Abduct. (rad.fl.)	R	39.7	6.1	34.4	9.5	+ 5.3	3.6	1.47
		L	45.4	9.6	41.0	10.1	+ 4.4	4.4	1.00
	Adduct. (uln.fl.)	*R	74.1	7.4	63.3	12.3	+10.8	4.5	2.40
		*L	74.5	6.7	63.6	10.4	+10.9	3.9	2.79
Thigh (at hip)	Flex. (forw.)	R	111.5	9.2	103.4	18.5	+ 8.1	6.5	1.24
		L	112.9	9.6	100.7	17.2	+12.2	6.2	1.98
	Exten. (backw.)	R	56.4	10.4	47.1	12.1	+ 9.3	5.0	1.86
		L	52.1	8.2	47.7	14.2	+ 4.4	5.2	.84
	Abduct.	R	79.3	10.4	74.7	14.0	+ 4.6	5.5	.83
		L	79.4	10.0	70.7	13.4	+ 8.7	5.3	1.64
	Int.Rot.	*R	73.0	16.6	54.3	10.8	+18.7	6.2	3.01
		*L	76.2	14.5	51.6	7.8	+24.6	4.6	5.34
	Ext.Rot.	R	45.6	6.7	36.1	13.1	+ 9.5	4.6	2.06
		L	39.2	8.4	34.0	10.0	+ 5.2	4.1	1.26
Lower Leg (at knee)	Flex.	*R	139.9	6.8	109.7	12.3	+30.2	4.4	6.86
		*L	136.3	7.6	107.8	11.0	+28.5	4.2	6.78
Foot (at ankle)	Plant. Flex.	R	36.1	9.9	29.7	12.7	+ 6.4	5.1	1.25
		L	35.3	11.2	29.9	12.0	+ 5.4	5.2	1.03
	Dors. Flex.	R	43.9	4.7	39.2	11.1	+ 4.7	3.8	1.23
		L	44.5	7.4	42.7	12.7	+ 1.8	4.6	.39

though not indicated in the tables, is that in certain movements (voluntary and passive flexion of the lower leg on both sides of the body) the distribution of measures of the two groups are completely exclusive. For these movements, all of the mentally deficient subjects show a smaller amplitude of movement than any of the mentally normal subjects. For all other movements examined, though there are differences in the arithmetic means of the two groups, the distributions overlap. The range of measures in the mentally normal and mentally deficient groups is shown for some illustrative movements in Figure 1. The movements represented are all those on the left side of the body for which the differences between the means for the two groups are statistically significant (in terms of a ratio t greater than or equal to 2.1).

IV. DISCUSSION

A. Reliability of results.

The results summarized above indicate that for the large majority of movements examined, the mentally deficient of the particular type and level examined show deficiencies in amplitude of joint movement compared with the mentally normal group. It is necessary to consider the extent to which this result may be regarded as reliable.

To determine the possible influence upon the means of so-called chance factors as represented by the dispersion of measures in the various distributions, the ratios t of the differences of the means to the standard errors of the differences have been determined. As already indicated, about one-third of the movements show statistically reliable differences in terms of a ratio t greater than or equal to 2.1. Even for the other movements, however, it must be regarded as significant that the differences between the mentally normal and mentally deficient groups are predominantly of the same sign, corresponding to a decreased amplitude of movement in the case of the mentally deficient. It is not unlikely that the use of larger groups of subjects would lead to statistically reliable differences in the case of many of the other movements. The effect of an increase in the number of cases in increasing the reliability of difference may rest on two factors: (1) the decrease in the value of the S.D. means and the derived $S.D._{diff.}$ as the number of cases increase, if the S.D. of the distributions remain about the same, and (2) the decrease in the critical ratio t that may be accepted as an index of statistical significance.

The adoption of a ratio for t equal to 2.1 as a criterion of statistical significance is based on Fisher's discussion of the statistics of small numbers (2). Fisher states that in a distribution containing a large number of cases, a critical ratio of 2 may be regarded as a satisfactory criterion of statistical significance (2, p. 113). If differences of means are being compared, a ratio of t equal to 2 corresponds to a probability of .975 that the "true" difference is greater than zero. (The corresponding value of the probability P, as defined by Fisher equals .05). If, however, a relatively small number of observations make up the distribution, then a somewhat greater ratio t is required to provide the same probability of a difference greater than zero. The tables of Student given in Fisher's book permits one to calculate how much greater this ratio must be. In the present study, 10 subjects were used in each experimental group. The corresponding number of degrees of freedom in the two groups is therefore 18, or two less than the number of subjects. Examination of Student's table of t values shows that for 18 degrees of freedom, a ratio t equal to 2.1 is necessary to provide a probability "P" equal to .05. A probability P equal to .05 corresponds to the probability of a difference greater than zero of .975. We have therefore adopted a ratio of t equal to 2.1 as a criterion of statistical significance in the present study. The value of the ratio of

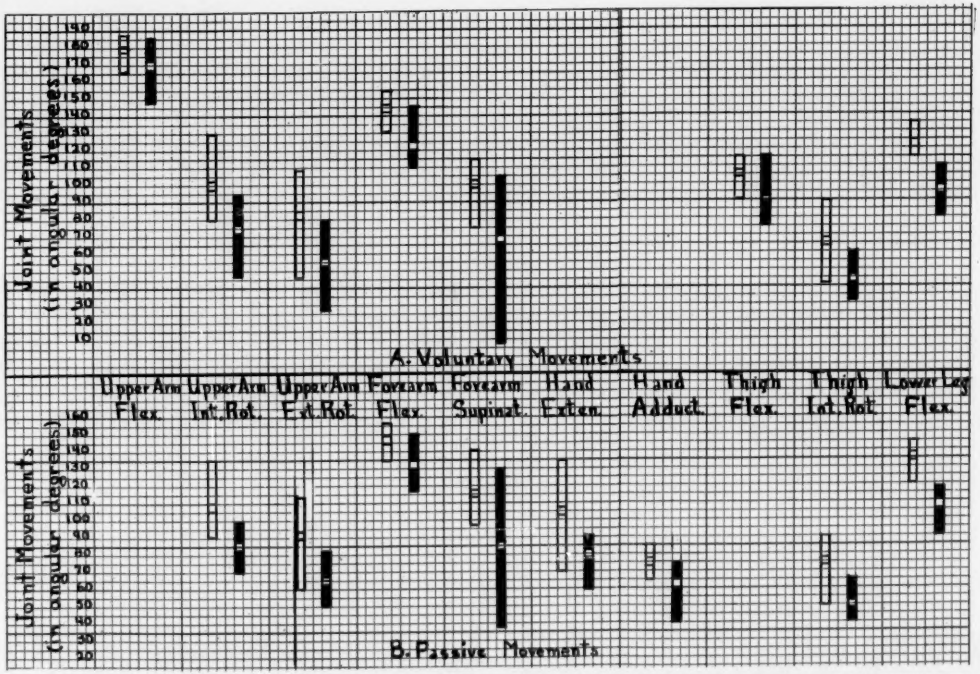

Figure 1. - Comparison of mentally normal and mentally deficient groups in range of variation of maximum amplitude of joint-movement for (A) voluntary movements, and (B) passive movements. The movements represented are all those on the left side of the body for which significant differences between the means of the two groups were found. Names of movements refer both to voluntary movements represented in upper part of chart and to passive movements in lower part of chart. Average values for various movements are indicated by small white squares drawn within the larger rectangles.

t used as a criterion of statistical significance is thus not appreciably altered by taking into account the limited number of cases. The advantage in the present instance of using the procedures outlined by Fisher lies, then, not so much in the quantitative effects upon t, but in the fact that we are provided with a theoretically sound basis for the determination of statistical significance, even when the number of cases is relatively small.

Sampling errors represent a second type of errors that may be involved in the results reported above. Tests for determination of statistical significance are not capable of exhibiting the extent to which sampling errors may be present. The results reported can therefore be regarded as but tentative and suggestive. To eliminate the possibility of such errors being present, similar investigations should be carried out with larger groups of subjects, selected under a variety of laboratory and institutional conditions. In such further investigations, time and labor might be saved by limiting the joints-movements examined to those in which the most marked and significant differences were found in the present study.

The possibility also exists that constant errors have influenced the results. Under this caption might be included any conditions that might have led the measurements of the mentally deficient subjects to deviate in a constant direction from the measurements of the normal group. We are not aware of the existence of such conditions in the present study, since care was taken to examine all subjects under precisely the same conditions. The carrying out of similar investigations by others in different laboratories is the best means for checking on the possible influence of errors of this type.

B. Amplitude of joint-movement and type of mental deficiency.

It should be borne in mind that the results reported above of limitations in amplitude of joint movement in the feeble-minded were obtained on a group of subjects selected on a particular basis. The results do not indicate, therefore, that similar limitations are to be expected in all types of mental deficiency. The existence of such associated defects of movements is likely to depend on the etiological type involved. It is commonly reported, for example, that individuals with mongolism are capable of an excessively wide range of movements at the joints. The tendency to deficiencies in amplitude of joint movement in the mentally deficient group of the present study suggests the desirability of a systematic and careful examination of the amplitude of joint movement among different etiological types and mental levels.

The mentally deficient group examined in the present study was itself not altogether homogeneous with respect to etiology. Half of the subjects was designated by the clinical division of the department as probably belonging to the hereditary type of mental deficiency. Etiology in the remaining subjects was specified as unknown. These subjects were like those in the hereditary group insofar as they were designated as belonging to "no special clinical type." It is quite likely that in the case of these subjects too, the mental deficiency is hereditary in origin. The data on family history, however, was not complete enough to permit this classification. It would be methodologically desirable in future studies of this sort if the various groups examined were made as homogeneous as possible with respect to probable etiology.

C. Measurements of joint-movements as a possible aid to diagnosis.

The results reported of differences in amplitude of joint movement in mentally deficient and mentally normal subjects raises the question of whether measurements of the type used might not be of help in the diagnosis of mental deficiency In the case of voluntary and passive movements at the knee joint, for example, the distribution of measures in the two groups of subjects did not even overlap. The confirmation of such results upon larger groups of subjects of various etiological types and mental levels would justify the use of such measurements as an additional diagnostic sign, assuming that factors other than mental deficiency that might be associated with deficiencies in joint amplitude were controlled.

D. Physiological factors underlying deficiencies in amplitude.

We may now inquire concerning the physiological factors which may have been responsible for the limitations in amplitude of joint movement found in the mentally deficient group. Factors of two kinds may be considered: (a) those which if increased in magnitude would lead to an increase in amplitude of joint movement; and (b) those which if increased in magnitude would lead to a decrease in amplitude of joint movement. We may refer to the former as facilitative factors and to the latter as restrictive factors. The facilitative factors, in the case of voluntary movement, consist of (1) degree of effort exerted by the subjects; and (2) the strength of the protagonist muscle groups, or more precisely, the torque which the protagonist muscle-groups provide for movement in a given direction when the subject makes his maximum effort. A decreased magnitude of these facilitative factors might help to account for a decrease in amplitude of voluntary movement in the mentally defective group. The assumption of such a decrease could not, however, explain the parallel decrease in amplitude of movement found in passive movements. In the case of passive movements, the strength and effort of the subject are not factors at all, inasmuch as the examiner supplies the force necessary to produce movement at any given joint. It seems more plausible, therefore, to attribute the deficiencies in amplitude of joint movement in the mentally deficient group to an increase in magnitude of the restrictive factors. These factors may be involved in both the case of voluntary and passive movements. The factors that may be included under this heading are: (1) the tonus or resistance to stretch of antagonistic muscle groups, as dependent, for example, on the elasticity and on the stretch reflex of the muscles, and (2) the tension of ligaments enclosing the joint, and which oppose excessive movement at a joint. It seems likely that one or both of these factors were responsible for the limitations of joint movement exhibited by the mentally deficient group in the present study. To determine which particular factors were responsible would require further investigation.

E. Developmental basis of decreased amplitude of joint-movement.

The deficiencies in amplitude of movement found for the mentally deficient group suggests the possibility that in individuals of the type considered, associated deficiencies in maximum amplitude of joint movement and in intelligence may be based on common developmental factors. In this connection it would be of interest to investigate the course of development of amplitude of joint-movement in the mentally normal, and in the mentally deficient of various etiological types. Similar developmental investigations of the various factors influencing joint

movement outlined above would also be of value. Investigations of this sort may provide an indirect method for determining the nature of the defective developmental agents responsible for the limitations of development found among the mentally deficient.

V. SUMMARY

The purpose of the present study was to compare the maximum amplitude of voluntary and passive joint-movement in sample groups of mentally normal and mentally deficient subjects. It represents part of a more general investigation being made of the motor properties associated with mental deficiency of various types. The subjects in both the mentally normal and mentally deficient groups examined were adults and comparable in chronological age, height, weight, and absence of signs of neuro-muscular disorder. The mentally deficient subjects were of no special clinical type, and ranged in mental age from 9 to 9.9 years. Measurements were made at practically all joints of the body by means of a plumb-line goniometer.

The mentally deficient group fell beneath the mentally normal group in maximum amplitude of movement in about 90% of the joint-movements examined. In about one-third of the movements, the differences found between mentally deficient and mentally normal groups were statistically significant. The possible causes of these differences were considered, and a number of different directions of further research suggested.

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THE MENTAL AND LINGUISTIC SUPERIORITY OF ONLY GIRLS

EDITH A. DAVIS[1]

While engaged in a major study[2] of linguistic ability in children at three discrete age levels, 5 1/2, 6 1/2, and 9 1/2 years, the writer compared 97 only children with 166 twins and 173 non-only singletons, selected on a percentage basis representative of the Minneapolis-St. Paul population, using the father's occupation as the criterion. The number of only children was made approximately equal to half the number of twins and non-only singletons, because the major objective of the study was a twin-singleton comparison rather than comparison of only and non-only children. About 57 per cent of all the subjects were at the 5 1/2 age level, because it was recognized that the kindergarten year is of crucial importance in the child's adjustment. Of the only children, 53 were 5 1/2 years old, 19 were 6 1/2, and 25 were 9 1/2, but the ratio of only to non-only children was kept nearly uniform at all ages, and the sexes were equally represented at all ages.

Early in the analysis of the data it was apparent that although only boys were superior to non-only boys in their use of language, only girls were superior to non-only girls in numerous phases of development. The findings are presented here in the belief that a real sex difference may exist in only children. Emphasis has been placed on the 5 1/2 year group because the large number of cases at this age makes the findings especially significant.

Intelligence of children in the 5 1/2 and 6 1/2 year groups are measured by the Pintner-Cunningham Primary Mental Test, and scores on the Pressey Intermediate Classification Test were secured for the 9 1/2 group. The mean I.Q. for only children at 5 1/2 and 6 1/2 years is slightly higher than that for children with siblings, although Table I indicates that this is not true for only boys from the lower occupational groupings.

Scores on the Pressey Test tended to be rather high, but there is no reason to question the value of the test as a means of determining relative standing. The findings at 9 1/2 years are based on incomplete returns taken from school records. More scores are missing for only children than for other children, and there are fewer cases, so that the apparent lack of superiority of only children at this age may be due to an error of sampling.

Table 2 suggests the probability of a real superiority of only girls over other groups in performance on the Pintner-Cunningham Test. Nearly all the critical ratios are so high as to indicate statistical reliability.

Both only boys and only girls use longer sentences than do children with siblings, although the difference is more consistent in girls than in boys. The

[1] From the Institute of Child Welfare, University of Minnesota.

[2] Davis, Edith A. The Development of Linguistic Skill in Twins, Singletons with Siblings, and Only Children. University of Minnesota, Institute of Child Welfare Monograph Series Number XIV. In Press.

TABLE I

MEAN I.Q. OF ONLY AND NON-ONLY CHILDREN BY AGE, SEX, AND OCCUPATIONAL GROUPING

Age	Occup'l group	Only children					Non-only children				
		No.of boys	Mean I.Q	No.of girls	Mean I.Q.	No.of both sexes	Mean I.Q.	No.of boys	Mean I.Q.	No.of girls	Mean I.Q.	No.of both sexes	Mean I.Q.
*5½	Upper	13	108.1	13	114.2	26	111.1	45	106.2	46	104.5	91	105.3
	Lower	14	92.0	13	109.0	27	100.1	52	97.7	52	99.6	104	98.4
	All	27	99.7	26	111.6	53	105.6	97	101.6	98	101.9	195	101.7
*6½	Upper	4°	114.2	5	109.6	9	111.7	10	102.5	11	105.2	21	103.9
	Lower	5	100.6	4	114.0	9	106.3	12	98.7	11	102.9	23	100.8
	All	9	106.7	9	111.5	18	109.1	22	100.5	22	104.0	44	102.3
**9½	Upper	4	119.2	6	112.2	10	115.0	22	120.7	23	117.4	45	119.0
	Lower	5	114.2	6	116.3	11	115.4	22	107.4	24	116.8	46	112.3
	All	9	116.2	12	114.2	21°°	115.2	44	114.1	47	117.1	91	115.6

* Pintner-Cunningham Test Used. ° No Pintner-Cunningham score for one case.
** Pressey Test Used. °° No Pressey Score for four cases.

TABLE 2

COMPARISON OF THE MEAN SCORE OF 111.6 MADE BY 35 ONLY GIRLS ON THE PINTNER-CUNNINGHAM TEST WITH THE MEAN SCORE MADE BY OTHER GROUPS

Group	Number of Cases	Mean Score	S.D.	Mean S.D.	Critical Ratio
Twin boys	59	98.8	16.29	2.12	3.76
Twin girls	59	102.2	14.16	1.84	2.80
Singleton boys	60	103.8	16.05	2.07	2.02
Singleton girls	61	102.3	10.83	1.39	2.99
Only boys	36	101.4	18.72	3.12	2.49
All other girls	120	102.2	12.60	1.15	3.11
All other groups	275	101.8	15.12	0.91	3.50

findings of the major study indicate that mean length of sentence at the ages under consideration tends to increase at the rate of about half a word yearly. It is possible, therefore, to express this difference in terms of months of development as well as in number of words. Measured in this way, only children use a greater number of different words than do children with siblings. The mean annual increase in number of different words for all cases was 14.2 words, or 1.2 words per month. It is thus possible to obtain a quantitative expression of the advantage of only children at each age over comparable non-only children in the use of vocabulary. These findings are presented in Table 3.

"Onliness" apparently is as effective in inducing variety of word usage as ten

TABLE 3

ADVANTAGE OF ONLY CHILDREN OVER CHILDREN WITH SIBLINGS IN MEAN SENTENCE LENGTH AND IN MEAN NUMBER OF DIFFERENT WORDS USED, EXPRESSED IN NUMBER OF WORDS AND IN MONTHS OF DEVELOPMENT

Subjects Age in Years	Sex	Superiority of Only Children in Mean Sentence Length		Superiority of Only Children in Mean Number of different Words	
		Words	Months of Development	Words	Months of Development
5 1/2	Boys	.20	4	7.4	6
	Girls	1.16	28	18.2	15.2
	Both	.67	16	12.6	10.5
6 1/2	Boys	0	0	0	0
	Girls	.50	12	10.2	8.5
	Both	.25	6	2.3	1.9
9 1/2	Boys	1.20	29	22.4	18.7
	Girls	.71	17	14.8	12.3
	Both	.95	23	18.6	15.5
All	Boys	.31	7	8.5	7.1
	Girls	.94	22	15.7	13.1
	Both	.62	14	12.0	10.0

months of chronological age and increases the length of sentence as much as fourteen months of chronological age.

Since only children are more accustomed to the society of adults than are children with siblings, we should expect to find only children very much at ease in an experimental situation such as that set up for the collection of the remarks analyzed in this study. Only children did make a higher percentage of spontaneous remarks and asked rather more questions than non-only children. All the boys asked more questions than did the corresponding girls, but at 5 1/2 years the only girls asked more questions than the non-only boys. At 9 1/2 years the only children asked fewer questions than the non-only children, but this may be due to sampling, since few only children were studied at this age, and questions were rare in all 9 1/2 year old children. Although non-only boys made more spontaneous remarks than non-only girls, only girls at 5 1/2 and 6 1/2 years made the highest percentage of such remarks of any group. Tables 4 and 5 compare only and non-only children for spontaneity of response and number of questions.

At the close of the interview during which the child's remarks were recorded, the examiner rated all subjects for talkativeness and shyness. In these ratings and in length of time required to obtain 50 remarks only boys do not differ greatly from non-only boys, but only girls tend rather consistently toward less shyness and greater talkativeness than non-only girls. This is particularly true at 5 1/2 years. At this age 81 per cent of non-only boys and 74 per cent of only boys were not shy, as compared with 65 per cent of non-only girls and 81 per cent

TABLE 4

PERCENTAGES OF SPONTANEOUS REMARKS FOR ONLY AND NON-ONLY CHILDREN

Age in Years	Only Children			Non-only Children		
	Boys	Girls	Both Sexes	Boys	Girls	Both Sexes
5 1/2	83.2	88.0	85.6	79.8	72.4	75.2
6 1/2	82.0	88.6	85.2	80.6	77.8	79.2
9 1/2	82.2	60.4	70.8	70.8	61.6	65.4

TABLE 5

PERCENTAGE OF QUESTIONS FOR ONLY AND NON-ONLY CHILDREN

Age in Years	Only Children			Non-only Children		
	Boys	Girls	Both Sexes	Boys	Girls	Both Sexes
5 1/2	14.8	12.4	13.6	11.8	10.9	11.2
6 1/2	11.6	8.4	10.0	12.7	7.2	9.9
9 1/2	4.2	2.8	3.4	4.9	3.4	4.2

of only girls. The mean length of time required to secure 50 remarks is 13.5 minutes for both only and non-only boys, but the time for only girls is 13.1 minutes as compared with 14.5 minutes for non-only girls. At 5 1/2 years the difference is striking. The mean time for non-only boys is 12.9 minutes, for only boys 12.7 minutes; for non-only girls it is 13.3 minutes, but for only girls 10.1 minutes.

There may be a tendency for parents to send only girls to school as soon as permissible, but to keep only boys at home a little longer. The 48 twin girls in the 5 1/2 year group lacked 15 days of being exactly 5 1/2 years old, and their mean school experience was 13.5 weeks, while the 26 only girls lacked 10 days of being exactly 5 1/2 years old, but their mean school experience was 18 weeks. Only boys, on the other hand, were 8 days more than 5 1/2 years old, but had been in school only 15.6 weeks. Although this difference is probably due to sampling, it would be well to check the age at school entrance in future studies of only children.

At 5 1/2 years the articulation of only children was much better than that of twins, but not very much better than that of non-only singletons. The superiority of only girls over only boys in this regard was not so great as the superiority of non-only girls over non-only boys. Seventy-four per cent of only boys and 84.6 per cent of only girls had perfect articulation as measured by a rather lenient scale improvised for the purpose, but the corresponding percentages for non-only children were 51.3 and 70.1.

Table 6 summarizes the differences just discussed between only and non-only children at the 5 1/2 age level.

Although in most of the traits measured only boys are superior to non-only

TABLE 6

COMPARISON OF ONLY WITH NON-ONLY BOYS, AND ONLY WITH NON-ONLY GIRLS IN VARIOUS PHASES OF DEVELOPMENT AT 5 1/2 YEARS

Trait Measured	Boys			Girls		
	Only	Non-only	Difference in favor of only children	Only	Non-Only	Difference in favor of only children
I.Q.	99.7	101.6	-1.7	11.6	101.9	9.7
Mean length of sentence in words	4.65	4.46	.19	5.55	4.39	1.16
Mean number of different words	96.5	89.1	7.4	111.5	93.3	18.2
Number of spontaneous remarks	41.6	39.9	1.7	44.0	36.2	7.8
Number of questions	7.4	5.9	1.5	6.2	5.47	.73
Minutes required for interview	12.7	12.9	.2	10.1	13.3	3.2
Per cent rated very talkative	40.1	33.0	7.1	38.5	23.1	15.4
Weeks of school experience	15.6	15.9	-.3	18.0	15.2	2.8

boys, the difference is entirely consistent and much greater in the case of girls. The findings suggest that the only child situation may be extremely favorable to the intellectual and linguistic development of girls. Teachers in their discussions with the writer frequently referred to the only boys in their charge as "spoiled," "queer," or "nervous," but considered the girls well adjusted and normal. At all events, the possibility of a sex difference in only children should be considered in blocking out future studies. Such a difference may explain the conflicting results reported by students of only children.

A COMPARISON OF THE VIGOROUSNESS OF PLAY ACTIVITIES OF PRESCHOOL BOYS AND GIRLS[1]

EVALINE FALES

PROBLEM

One sex difference which has been little questioned is that of vigorousness of play activity. It has been taken for granted that boys take part in more vigorous activities than girls, and the few investigations which consider this problem seem to give supporting evidence.

Using the questionnaire method, Croswell (4) concluded that school-age boys are more interested in "amusements productive of motor development" than are girls. Lehman (7), using the checking method, states that boys participate more frequently in active plays and games, while girls tend to choose those of a sedentary type. This difference was reported even for his youngest subjects, who were five years old. McGhee (8), also using the checking method, had reported similar findings. Terman's (12) masculinity scale of play activities was constructed on the basis of the checking method and test questions. The more vigorous activities of the scale tend to be at the masculine end of the list and the less vigorous items at the other end.

It is doubtful whether either the simple questionnaire or the checking method has very much reliability when used with children. While the former may tend to cause recent activities to be overweighted, the latter is likely to suggest activities which might not otherwise be included. The observational method is a step towards more objective investigation of this problem.

On the basis of informal, uncontrolled observations of a group of kindergarten children in free play situations, Sisson (10) concludes that the older boys spent most of their time at active play; the older girls spent most of their time at dramatic play; and the younger children, both boys and girls, spent most of their time playing in the sand. A fourth group did little of anything.

The rest of the studies referred to are based upon controlled observation upon preschool children in free play situations.

Bridges (2), upon the basis of records of the per cent of time that each of ten three-year-olds spent at each play material, concludes that boys tend to choose equipment which promotes active play while girls choose materials which encourage quiet occupations. A later study made by the same investigator (3), using fourteen four-year-olds as subjects and using the number of choices of each material rather than the per cent of time, suggests that boys choose play equipment which encourages the use of large muscles while girls choose materials which promote finer co-ordination. Van Alstyne (13) in an elaborate study of play behavior concludes that boys choose materials which make for active play

[1] This study originated as a Master's Thesis at Mills College, under the direction of Dr. Harriet E. O'Shea. Subsequent work has been done at the Iowa Child Welfare Research Station, State University of Iowa, Iowa City, Iowa.

while girls tend to choose those which encourage more passive play.

Atkins (1), using the diary record method with five girls and five boys as subjects, states that sex has little influence upon type of play.

Although the above investigations indicate a difference in choice of play materials, conclusions regarding the total vigorousness of the children's activities do not seem justified. The judgment as to the vigorousness of an activity encouraged by the choice of a given play material is purely subjective. Moreover, the fact that one material can be used with varying degrees of vigorousness is entirely overlooked.

Although Sweeny, Hejinian, and Sholley (11) make no conclusions regarding sex differences, their study is of interest because of the method. This is the first attempt to differentiate between different degrees of vigorousness in a given activity. A five-point scale of vigorousness of eleven play categories was devised. Repeated short observations were made, recording the category of the play in which a child took part and the vigorousness of the participation as judged by the recorder at the time. Although this scheme permitted differences of vigorousness within each category, there was no way of judging differences from one category to the next.

Manwell and Mengert (9), using repeated short observations, checked a list of twenty-seven activities at one-minute intervals. One of the items on the list was physical activity. This was defined carefully and included play with mobile toys and large apparatus such as ladders, boxes, etc. The boys received a significantly higher score than the girls in this category. The score merely represents the number of times the item was checked and does not take into account degrees of vigorousness of physical activity.

Goodenough (6) used a similar but more refined technique. At the end of each fifteen-minute observation the child was rated with an appropriate number and letter according to the following categories:

0. No observable activity
1. Hand and arm movements only
   a. Active
   b. Strenuous
2. Hand, arm, trunk only
   a. Active
   b. Strenuous
3. Leg and trunk only
   a. Active
   b. Strenuous
4. Movements of whole body
   a. Active
   b. Strenuous

Even this method is subjective and lacks enough differentiation to give conclusive results.

PURPOSE

The purpose of this study was to investigate in a precise and objective manner sex differences in interest in vigorous activities and in quiet ones among preschool children as subjects.

METHOD

The method consisted of taking detailed diary records with the aid of a stop watch and classifying them according to A Rating Scale of the Vigorousness of Play Activities of Preschool Children (5) which was devised for the purpose of this study.

This scale consists of 651 items or activities in which preschool children engage. The items have been arranged into forty-eight levels of vigorousness by ten expert judges. This gives each item on the scale a vigorousness rating of from 1 to 48 depending upon which level of vigorousness it is in. Ratings of 1 represent the lowest degree and 48 the highest degree of vigorousness. The judges agreed highly in their classification of activities, the correlation of the ratings of half of the judges against those of the other half being .90.

SUBJECTS

The subjects were thirty-two preschool children, sixteen boys and sixteen girls, paired as nearly as possible according to chronological age. There were not enough children available to consider mental age and IQ in the pairings.

The children were selected from four different preschools in order that the group might be as unselected as possible. Seven pairs were taken from the Mills College preschool laboratory. The children were from American families above average in social status. Six pairs were taken from the Institute of Child Welfare at the University of California preschool. These children were mostly from professional families. Two pairs, Italians, and one pair of Russian twins were from philanthropic preschools of the Golden Gate Kindergarten Association in San Francisco. These children were from homes of low economic status. In spite of these three pairs, the group as a whole represents homes above the average. Table 1 gives more information about the subjects.

PROCEDURE

Recording the Data

The data consisted of detailed diary records including each activity in which the child engaged, together with the number of seconds spent at this activity. It was necessary for the recorder to be familiar with the items on the rating scale and to be experienced in recording with the aid of a stop watch.

In taking the data, time was equated carefully. Both children of a pair were observed upon the same day. Two observations were made upon each child, always upon consecutive days. The observations were arranged in such a way that if boy

TABLE 1

SEX, CHRONOLOGICAL AGE, MENTAL AGE, AND INTELLIGENCE QUOTIENT OF SIXTEEN BOYS AND SIXTEEN GIRLS

Boys*				Girls*			
Boy	Chronological Age	Mental Age	Intelligence Quotient	Girl	Chronological Age	Mental Age	Intelligence Quotient
1	25.5	30.6	120	1	24.0	22.3	93
2	29.0	30.2	104	2	26.5	27.5	104
3	34.0	46.6	140	3	34.0	38.4	113
4	35.0	42.2	120	4	35.5	43.0	121
5	34.0	55.4	163	5	36.0	41.8	116
6	36.0			6	36.0		
7	37.0	53.7	145	7	37.0	48.1	130
8	38.5	43.1	112	8	38.5	46.2	120
9	39.0			9	39.0		
10	42.0	53.8	125	10	42.5	56.5	133
11	42.5	48.5	114	11	43.5	58.3	135
12	47.0	58.8	125	12	44.0		
13	46.0	52.4	114	13	47.0	52.1	111
14	46.0	56.1	122	14	48.0	55.2	115
15	50.0			15	52.0		
16	53.0	61.5	116	16	54.0	56.1	103
Mean	39.9	48.5	126	Mean	39.9	45.3	117
S.D.	7.2	9.4	15.9	S.D.	7.9	11.1	13.0

*N=16

A were observed during the first part of the morning and girl A during the last part, on the following day girl A would be observed during the first part of the morning and boy A later.

Each of the two observations made upon a child was somewhat over forty minutes long. It was desired to retain two forty-minute records for each child after activities which had been influenced by adults and those few which could not be classified according to the scale had been eliminated. The final data consist of two forty-minute observations for each child except girl D, whose record is for thirty-four minutes and thirteen seconds.

The teachers in the group were aware of which child was being observed and tried to influence his activities as little as possible. The children were observed in a free play situation, almost always out of doors.

In each of the preschool situations there was approximately the same possibility for activity, the equipment being very similar.

Classification of Data

The diary records were classified according to the rating scale. For each item on the diary record the duplicate was found in the rating scale. Then the number of seconds spent at this activity as indicated by the diary record was multiplied by the vigorousness level as indicated by the rating scale. This product was called the multiplied score, and the total of the multiplied scores divided by the number of seconds represented in the record was the child's vigorousness score.[1]

[1] A few items, of the type which is self-limiting and therefore more vigorous the less time it takes to complete the activity, could not be treated in this manner, but corrected multipliers were used in place of the time (5).

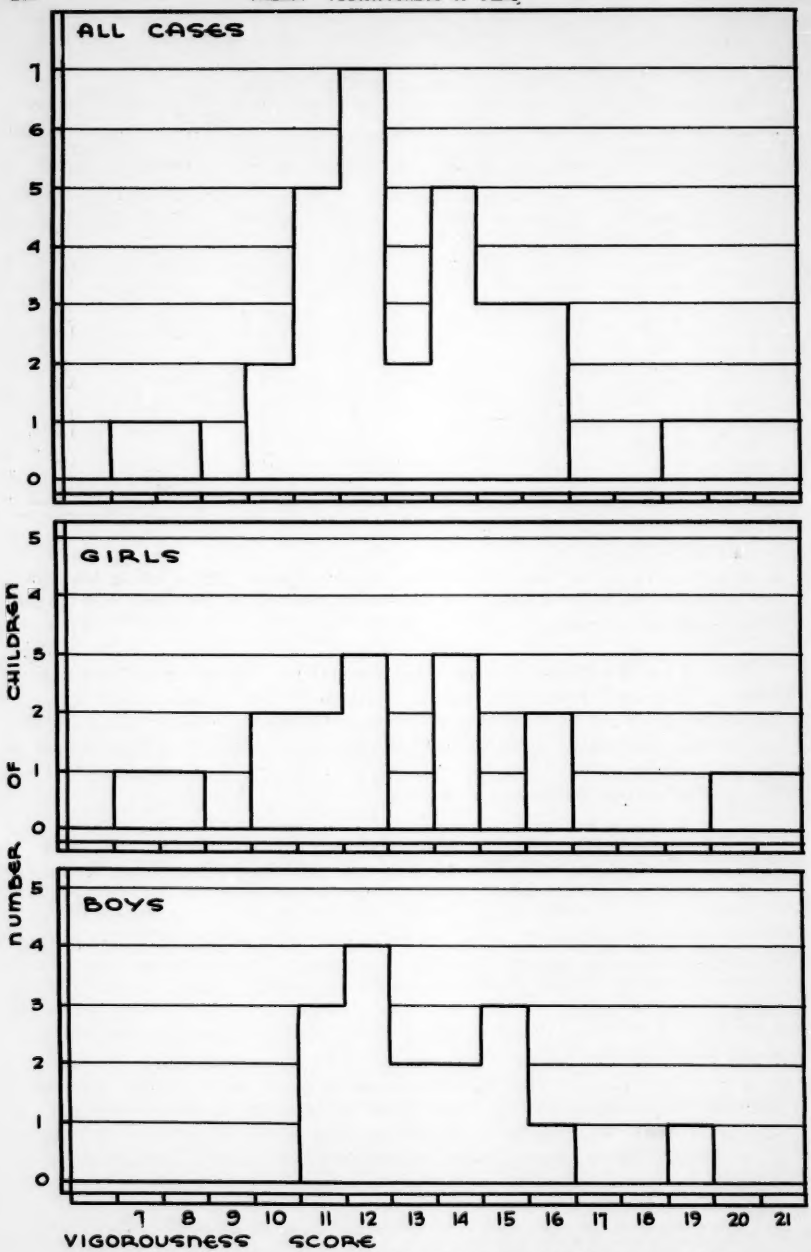

Figure 1. Distribution of the Children According to Vigorousness Score.

TABLE 2

MEAN VIGOROUSNESS SCORES FOR SIXTEEN BOYS AND SIXTEEN GIRLS

Boy	Boys* Observation		Mean	Girl	Girls* Observation		Mean
	First Hour	Second Hour			First Hour	Second Hour	
1	15.98	14.73	15.35	1	8.42	11.69	10.05
2	19.81	18.96	19.38	2	17.55	23.33	20.44
3	14.29	11.36	12.83	3	14.52	4.57	9.54
4	10.24	11.52	10.88	4	14.17	27.38	20.77
5	13.56	13.73	13.64	5	9.74	13.12	11.43
6	14.10	10.16	12.13	6	15.79	12.43	14.11
7	12.33	14.12	13.22	7	18.62	10.07	14.34
8	10.86	16.85	13.85	8	13.19	11.77	12.48
9	14.99	14.62	14.81	9	15.32	12.94	14.13
10	18.33	14.57	16.44	10	12.47	8.99	10.73
11	15.92	13.14	14.53	11	15.37	9.46	12.41
12	10.20	12.41	11.30	12	10.86	20.48	15.67
13	14.94	8.43	11.68	13	10.86	20.37	15.61
14	11.58	12.80	12.19	14	8.07	6.57	7.32
15	11.66	13.32	12.49	15	13.77	10.79	12.28
16	13.02	9.61	11.31	16	9.05	6.27	7.63
Mean	13.86	13.15	13.50	Mean	12.99	13.14	13.06
S.D.	2.69	2.56	2.14	S.D.	6.28	6.26	3.70

*N=16

Reliability of Taking the Data

In order to measure the reliability of taking data in this manner, two independent recorders took thirty-four five-minute records simultaneously. When each five-minute record was classified according to the rating scale, the correlation between the vigorousness scores representing the records of the two different recorders was .98 ± .01.

RESULTS

Central Tendencies

Table 2 shows the vigorousness scores for the children. The mean score for the boys is 13.50 and for the girls 13.06. These scores are very nearly alike and the difference is not statistically significant. When the difference between the means, .44, is divided by the standard error of the difference, the critical ratio is .41.

There is much variability within the group, and somewhat more among the girls than among the boys. The standard deviation of the girls' means is 3.70, while for the boys it is 2.14. The girls show a wider range in vigorousness scores; both the least vigorous child and the most vigorous child are girls.

The following tabulation shows the distribution of the children according to their vigorousness scores. Figure 1 shows the same thing graphically.

Vigorousness Score	Boys	Girls	All Cases
7	0	1	1
8	0	1	1
9	0	0	0
10	0	2	2
11	3	2	5
12	4	3	7
13	2	0	2
14	2	3	5
15	3	0	3
16	1	2	3
17	0	0	0
18	0	0	0
19	1	0	1
20	0	1	1
21	0	1	1
Total	16	16	32

Distribution of Time at Different Levels of Vigorousness

Although the mean scores show no sex differences in interest in vigorous activity, it seemed possible that further analysis of the data might reveal differences. It is possible that there was a difference between the sexes as to how their total time was distributed among the different levels of vigorousness. One child might take part in only very vigorous and very quiet activities and show the same total score as another child who spent all of his time at activities of about average vigorousness.

In order to investigate this time distribution, time was tabulated for each vigorousness level. Then, in order to have fewer levels of vigorousness for this study, the levels were grouped in fours, making twelve degrees of vigorousness rather than forty-eight.

The following tabulation* shows the per cent[2] of total time spent at each level of vigorousness for the boys, for the girls, and for all cases. Figure 2 shows histograms of these distributions. The extreme similarity between the distributions of the boys and the girls is very striking. None of the differences in these distributions is statistically significant. The largest difference between the per cent of time spent by the boys and by the girls is in vigorousness level 1 to 4. The difference is 5.16, but when this difference is divided by the standard error of the difference, the critical ratio is only 1.89. The critical ratios for all of the other differences are much less. This shows that there is not only no sex difference in vigorousness as shown by the means, but that there is also no difference as shown by the distribution of the time among the levels of vigorousness.

* See page 152.

[2] Because of the fact that in a few items a corrected multiplier was used instead of the time in obtaining the multiplied score (See footnote 1, p. 147), there would be a slight difference as to whether the per cent of total time (using time for all items in the records) or the per cent of total vigorousness (using the corrected multipliers where they occur in the data) were used in this analysis of the distribution. The tabulation was made in each way and the discrepancy proved to be so slight that it makes no difference in the final results which of the two methods is used.

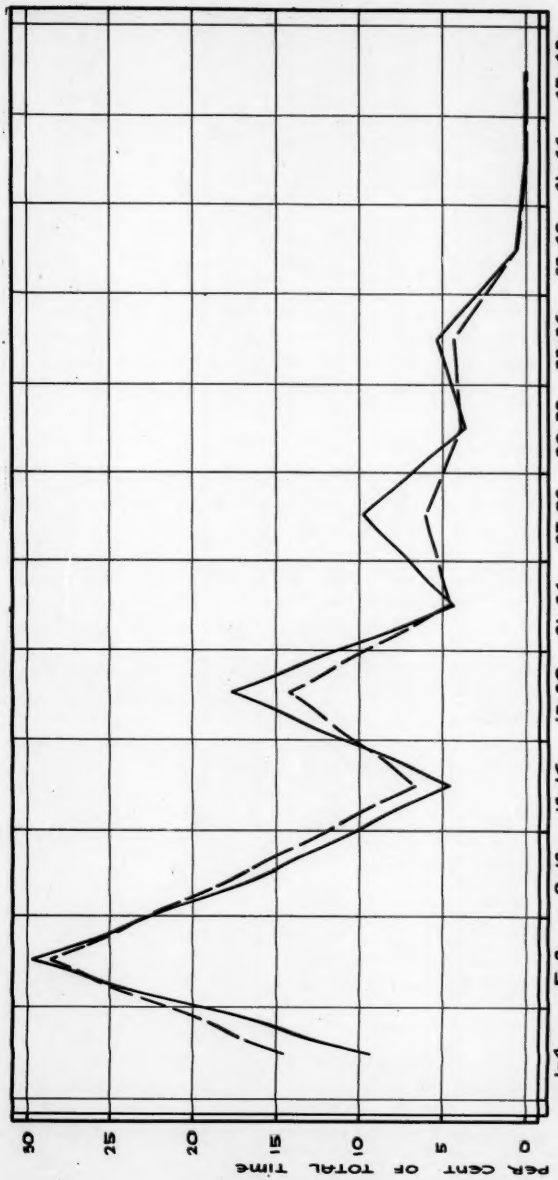

Figure 2. Distribution of Per Cent of Time Spent at Each Vigorousness Level for Boys and Girls.

Vigorousness Level	Boys	Girls	Differences	All Cases
1 to 4	9.51	14.67	5.16	12.09
5 to 8	29.77	28.45	1.32	29.11
9 to 12	15.00	16.77	1.77	15.89
13 to 16	4.66	6.68	2.02	5.69
17 to 20	17.45	14.23	3.22	15.84
21 to 24	4.29	4.61	.32	4.45
25 to 28	9.75	5.98	3.77	7.87
29 to 32	3.56	3.67	.11	3.62
33 to 36	5.31	4.32	.99	4.82
37 to 40	.64	.60	.04	.62
41 to 44	.01	.05	.04	.03
45 to 48	.05	.00	.05	.02

It is interesting to note that among both boys and girls a large per cent of the time is spent at the lower levels of the scale. Considering the boys and girls together, over 41 per cent of the total time observed is spent at vigorousness level 1 to 8. Over 57 per cent of the total time is spent in level 1 to 12.

Time of Day Differences

Another investigation which seemed of interest was to determine whether there were any differences in the vigorousness of the activities during the first part of the morning and during the latter part.

Two forty-minute records were obtained for each child, these records being on consecutive days but one always representing the first part of the morning and the other the latter part. The mean vigorousness score for all of the thirty-two children for the first hour was 13.42 and for the second hour 13.13. This is very nearly the same. When the difference of .29 is divided by the standard error of the difference, the critical ratio is .29, which indicates no significance.

Analyzing the data further, we find that there is also no significant difference between the vigorousness of the first and last hours if we consider the boys and girls separately. For the boys the mean score for the first hour is 13.86 and for the last hour 13.15. For the girls the mean for the first hour is 12.99 and for the second 13.14. This shows that the means reveal no significant time of day differences in vigorousness.

The data were further analyzed to determine whether there might be differences as to the per cent of time spent at each level of activity. Table 3 shows the per cent of time spent at each vigorousness level for each of the two-hour observations for the boys, the girls, and both together. Figure 3 shows histograms of these findings.

In only three of the vigorousness levels is the difference as much as 1 per cent. Both the boys and the girls spend more time taking part in activities of the lowest vigorousness level 1 to 4, during the last part of the morning. The reverse is true of the next two levels. Children spend more time at levels 5 to 8

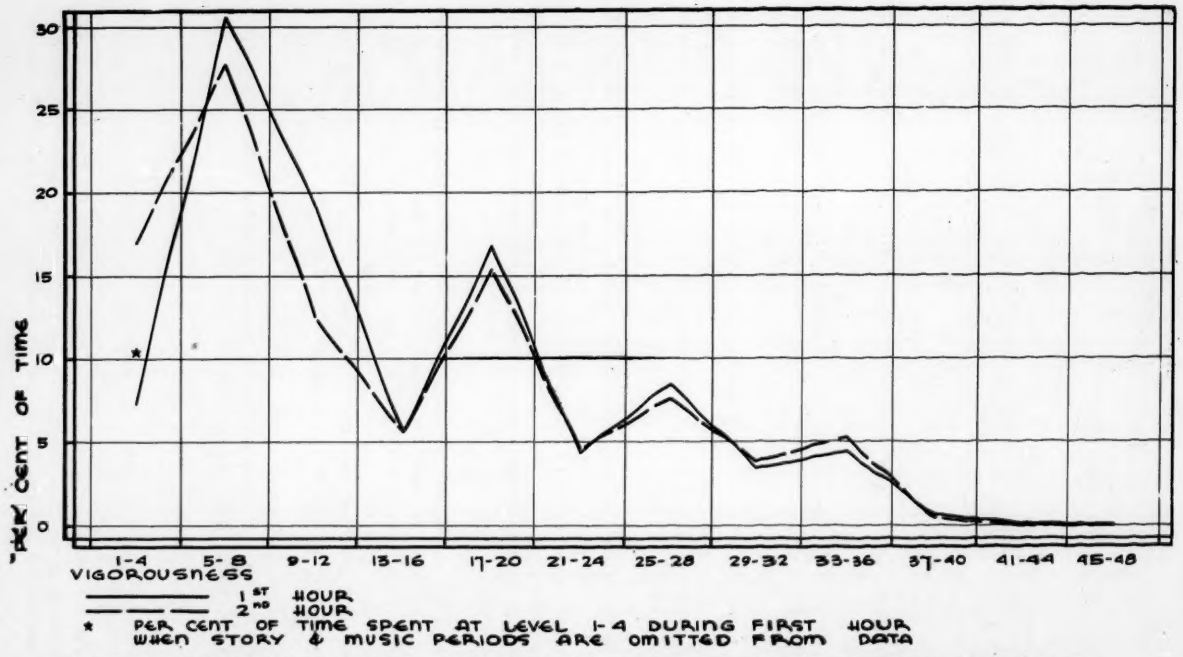

Figure 3. Distribution of Per Cent of Time Spent at Each Vigorousness Level During First and Second Hour.

TABLE 3

DISTRIBUTION OF PER CENT OF TIME SPENT AT EACH VIGOROUSNESS LEVEL DURING FIRST AND SECOND HOUR

Observation	Vigorousness Level											
	1 to 4	5 to 8	9 to 12	13 to 16	17 to 20	21 to 24	25 to 28	29 to 32	33 to 36	37 to 40	41 to 44	45 to 48
Boys												
First Hour	6.54	29.83	18.20	4.96	18.10	4.85	8.47	3.21	4.95	.84	.02	.10
Second Hour	12.57	29.72	11.81	4.37	16.80	3.73	11.01	3.92	5.66	.43	.00	.00
Difference	6.03	.11	6.38	.59	1.30	1.12	2.53	.71	.75	.41	.02	.10
Girls												
First Hour	7.91	31.45	20.01	6.29	14.45	3.66	8.15	3.51	3.88	.60	.11	.00
Second Hour	21.43	25.46	13.53	7.01	14.01	5.53	3.80	3.84	4.76	.61	.00	.00
Difference	13.52	5.99	6.48	.72	.44	1.87	4.35	.33	.88	.01	.11	.00
Both Sexes												
First Hour	7.23	30.64	19.11	5.63	16.28	4.26	8.31	3.36	4.42	.72	.07	.05
Second Hour	17.00	27.59	12.67	5.69	15.41	4.63	7.41	3.88	5.21	.53	.00	.00
Difference	9.77	3.05	6.44	.06	.87	.37	.90	.52	.79	.19	.07	.05

and 9 to 12 during the first part of the morning than during the latter part. In no case except in level 1 to 4 is the difference significant. This difference of 9.77, when divided by the standard error of the difference, gives a critical ratio of 3.53.

In one of the preschool situations in which the observations were made, a story period was sometimes held during the latter part of the morning. Although no verbal suggestion was made that the children join the group, this activity was made somewhat more available during the last period of the morning. Sitting listening to stories has a vigorousness of 2 and therefore would be within the 1 to 4 level.

In order to see how much effect the story period had, the time which any children spent sitting listening to stories was cut out of the data. Also two short periods of sitting listening to a music period were eliminated. This eliminated 4,126 seconds of data during the second hour of the girls' observations and 130 seconds of the first hour and 1,139 seconds of the second hour of the boys' observations. Records of six girls and four boys were involved.

When the per cent of total time spent in level 1 to 4 was worked after the story and music periods had been eliminated from the data, quite different results were obtained. The results follow:

Hour	Boys	Girls	All Cases
1	6.20	7.91	7.05
2	9.61	10.67	10.14

The per cent of time is still slightly greater for the second hour, but the difference is no longer statistically significant. Thus we find that the only difference due to time of day was the result of more quiet activity being made

available at one time than at another.

In the analysis of the difference due to time of day we again find a striking similarity between the distributions of the boys and the girls.

Day-to-Day Differences

There was much variability from one day to the next. The correlations between Observation 1 and Observation 2 (this is not the same as first hour and second hour) were .38 for the boys and .15 for the girls.

Relation Between Vigorousness and Other Factors

In order to ascertain whether vigorousness has any relation to chronological age, mental age, or IQ, correlations were calculated. They will be found in Table 4.

TABLE 4

RELATIONSHIP BETWEEN VIGOROUSNESS AND OTHER FACTORS

Variants	Girls		Boys		Both Sexes	
	r	P.E.	r	P.E.	r	P.E.
Corrections of Zero Order						
Chronological Age and Vigorousness	-.34	.15	-.47	.13	-.44	.10
Mental Age and Vigorousness	-.33	.17	-.58	.13	-.30	.12
IQ and Vigorousness	.06	.19	-.19	.18	.00	.14
Chronological Age and Mental Age	.88	.05	.84	.05	.85	.04
Chronological Age and IQ	.55	.14	-.16	.18	.00	.14
Mental Age and IQ	.66	.11	.38	.14	.28	.13
Correlations of First Order						
Chronological Age and Vigorousness (Mental Age Constant)	-.11		-.05		-.22	
Mental Age and Vigorousness (Chronological Age Constant)	-.08		-.38		-.03	
IQ and Vigorousness (Mental Age Constant)	.40		.04		.12	
IQ and Vigorousness (Chronological Age Constant)	.32		-.30		.00	
Chronological Age and IQ (Mental Age Constant)	-.07		-.97		-.46	
Mental Age and IQ (Chronological Age Constant)	.44		.98		.53	
Correlations of Second Order						
Chronological Age and Vigorousness (Mental Age and IQ Constant)	-.09		.33		-.19	
Mental Age and Vigorousness (Chronological Age and IQ Constant)	-.25		-.43		-.04	
IQ and Vigorousness (Chronological Age and Mental Age Constant)	.39		.04		.02	

In the correlations of zero order we find a significant negative correlation between chronological age and vigorousness and between mental age and vigorousness - the former -.44 ± .10 and the latter -.38 ± .12. It seems that in a nursery school situation children with low chronological and mental ages tend to take part in more vigorous activities than the children chronologically and mentally older. There is no significant relation between IQ and vigorousness.

In order to find which factor is the most closely associated with vigorousness, partial correlations were found. From these correlations it seems that vigorousness is more dependent upon chronological age than upon mental age. The partial correlation between chronological age and vigorousness, holding mental age constant, is -.22. The partial correlation between mental age and vigorousness, with chronological age constant, is -.03.

This tendency of the younger children to take part in more vigorous activities than the older children might be due to their habit of running about from one thing to another, while the older children frequently settle down to one activity for some time. Further analysis of the data would indicate whether this supposition is correct.

Reliability of Data

The reliability of the data as measured by a rank correlation of the vigorousness scores between the odd and even five-minute periods of the observations is high. After being corrected by the Spearman-Brown formula, the correlation for the boys is .88 ± .09, for the girls .93 ± .06, and for both together .92 ± .03.

SUMMARY

1. The purpose of this study was to study sex differences in vigorousness activities.

2. The subjects were thirty-two preschool children, sixteen boys and sixteen girls, paired according to chronological age.

3. The procedure was to take detailed diary records, two forty-minute records for each child, and classify them according to the Scale of the Vigorousness of Activities of Preschool Children. In this way a vigorousness score was obtained for each child.

4. The mean vigorousness score for the boys was 13.50 and for the girls 13.06. This difference is not statistically significant.

5. Much variability is shown within the groups, the girls showing more variability than the boys.

6. The per cent of total time was found in each of twelve large levels of vigorousness (the forty-eight levels being grouped into fours). The boys and girls showed similar distributions, no significant difference being found in any level.

7. Both the boys and the girls spent a large per cent of time in the lower levels of vigorousness, over 57 per cent of their total time being spent at level 1 to 12.

8. When the effects of a few instances in which more quiet activities were available during one part of the morning than at other times were eliminated, there

were no significant differences due to time of day in the vigorousness of the activity. In this analysis also the girls and the boys showed striking similarity.

9. There was great variability of vigorousness of activity from one day to the next.

10. There is a slight tendency for the younger children to have higher vigorousness scores than the older children.

11. The data are reliable as shown by correlations between the odd and the even five-minute periods. The correlation is .92 when corrected by the Spearman-Brown formula.

CONCLUSIONS

This study shows striking similarity between the vigorousness of the activities of preschool boys and girls. Not only are the mean vigorousness scores almost identical, but the per cent of total time they spend at each vigorousness level is almost the same. This is true for both the first hour and the last hour of the morning. Moreover, the mean scores of the boys and the girls for the first and the last hours are very much alike.

These striking similarities in every comparison which was made seem to eliminate the possibility that the likeness is due to chance and would disappear if more cases were used.

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THE EFFECT OF TRAINING ON RHYTHMIC ABILITY AND OTHER PROBLEMS RELATED TO RHYTHM

MINNIE GIESECKE WIGHT

In an effort to make some useful contribution to the motor phase of the educational program at the Country Home for Convalescent Crippled Children, in Chicago, a general study of rhythm was undertaken at that institution during the winter and spring of 1936 by the writer, under the direction of Professor Frank N. Freeman, of the University of Chicago.

For a description of the Country Home and its educational activities, the reader is referred to an article[1] by Loretta Maud Miller in Occupational therapy and rehabilitation of August, 1934. By way of brief explanation, however, the Country Home for Convalescent Crippled Children is an institution affiliated with the University of Chicago and located in the country some forty miles west of the city of Chicago. Its purpose is the provision of convalescent care for children referred from various hospitals in Chicago, but particularly from the orthopedic hospital in the University Clinics. Almost all cases admitted to the Home involve some form of disturbance of the skeletal structure of the body, and facilities for as many as one hundred children, including bed, semi-ambulatory, and ambulatory patients, are found in the Home.

Since convalescence in orthopedic cases frequently covers an extended period of time, and since the typical age range included in the group of patients is from four to fourteen years, educational as well as medical care is provided. As part of a research program in connection with the educational department of the Country Home, this investigation of some of the problems of rhythm was instituted.

DESCRIPTION OF THE TESTS

The two chief questions for which answers were sought in this study were: first, is rhythmization an ability which can be increased by training; and, second, is there a relationship between rhythmic ability and general motor ability.

In order to attack either of these problems, it became necessary to develop a rhythm test or tests which would be suitable for use in the Country Home situation and which would meet the demands of scientific standards as to reliability. Similarly, in order to attempt to find an answer to the second question, a suitable motor coordination test needed to be determined upon.

On the assumption that a test of ability to reproduce rhythm patterns would be a test of ability to rhythmize, considerable preliminary work was devoted to the construction of such a test. First efforts made use of a revolving disc operated by a phonograph motor. On the disc were placed contacts so arranged that the following rhythm pattern was produced by strokes of a magnetic hammer, to which the disc was wired:

[1] Loretta Maud Miller, "Educational work for orthopedic children," Occupational therapy and rehabilitation, vol. 13, No. 4, August, 1934, pp. 223-232.

Tap, tap, tap, pause, tap, pause,
Tap, tap, tap, pause, tap, pause, etc.

Included in the circuit was an especially devised tapping board and a kymograph on which could be automatically recorded, in ink, both the rhythm pattern set by the hammer and the response tapped on the keys of the tapping board. The kymograph was equipped with a time-line pen.

The tapping board devised for this preliminary study was made up of a set of six keys arranged in a circle having a diameter of eight inches. The keys were placed equidistant from one another and their positions were fixed. Slight pressure on any one of the keys depressed it sufficiently to make contact with a brass plate, closing an electric circuit. This closure operated an electric marker, and this, in turn, produced sideward movement of the kymograph pen. Paper passing under the kymograph pens received this automatic record of performance on the tapping test. This tapping mechanism was utilized both for a response key in the rhythm test and as a special motor coordination test.

Using a group of 28 of the older children available at the time, a preliminary study was made through which techniques were determined upon for both the rhythm and the motor coordination tests to be used in the main study. Following this preliminary study, improved equipment was secured.

A new disc was constructed, on which were set contacts so arranged that the following four different rhythm patterns, of graduated difficulty, could be sounded by the magnetic hammer:

Pattern I	Tap, pause, tap, pause, tap, pause, etc.
Pattern II	Tap, tap, tap, pause, tap, tap, tap, pause, etc.
Pattern III	Tap, tap, tap, pause, tap, pause, Tap, tap, tap, pause, tap, pause, etc.
Pattern IV	Tap, tap, pause, tap, tap, tap, pause, pause, Tap, tap, pause, tap, tap, tap, pause, pause, etc.

In place of the phonograph motor, an electric motor with a rheostat was attached to the disc, insuring constant speed in the rhythm pattern. A switch was attached so that the hammer could be turned on and off at will.

A new tapping mechanism also was constructed, similar to the original one but larger in diameter (11" in place of 8"), in order to utilize larger arm movement for the motor coordination test.

Rhythm tests.--The following technique was adopted for the rhythm tests. An explanation was given of the object of the test; the hammer was sounded and the key most convenient to the child (depending upon hand-preference and upon type of physical handicap) was tapped by way of demonstration; finally, the child was asked to tap on the key in unison with the sound. Two successive trials (made up of a series of repetitions of the pattern specific in number for each of the four rhythm patterns) were given, followed by an explanation that in the next trial the child should again "do his best to tap right with the sound," but that "after a

while" (actually at the end of a series of equal length with each of the first two trials) the sound would be turned off and he should "keep right on tapping in the same way" until told to stop. This last series was equal in length to each of the first three. Thus, four trials of equal length were given, the first three requiring performance in unison with the sound of the hammer, and the last requiring reproduction of the rhythm pattern without the sound stimulus.

Each of the four patterns was presented in this way, and trials were taken on all, unless it was found that a child was unable to follow the pattern during the entire first trial. In that case no further trials were undertaken.

Pattern IV was found to be too difficult to be useful with so young a group of children. Pattern III was also too difficult for most of the younger children, although satisfactory for the older ones. Pattern II, however, was suitable throughout the entire age scale, although perhaps a little too easy at the upper age levels. Unless otherwise indicated, therefore, reference hereafter to the rhythm test is reference to performance on Pattern II of the rhythm tests.

In scoring the rhythm tests, the first two performances of the pattern were considered to be preliminary and were not scored. In the case of Pattern II, the score was then based upon twelve repetitions of the pattern, which produced 38 intervals between taps. Each interval was measured and counted correct if within a tolerance of 10% plus or minus; otherwise, incorrect. A possible score of 38 could thus be achieved on Pattern II.

The score for each trial was translated into terms of percentage accuracy. It was found, upon retesting, that the highest reliability was secured by using as the final score an average of the scores on the four trials. The test was therefore so scored.

Motor coordination tests.--Two types of performance were secured with the use of the tapping mechanism as a motor coordination test. The first involved speed of tapping back and forth on two adjacent keys. Explanation and demonstration indicated the object of the test, which was to tap back and forth on the two keys as rapidly as possible during a period of eleven seconds. Two successive trials were given, and each was scored in terms of total number of taps recorded on the kymograph paper during the eleven-second interval. The exact time-interval was indicated on the kymograph paper by the time-line pen. For the final score on this two-key tapping test, the scores on the two trials were averaged.

The second tapping test required tapping for speed on all six keys in consecutive order, and again two trials were given. This test involved full arm movement, while the two-key test required movement only of the hand and forearm. The same time-interval and the same scoring method were used for this six-key as for the two-key tapping test just described.

Since these two tests showed almost equal reliability, and because the six-key test was thought to involve more complex motor coordination than the two-key test, the former was used for all comparative purposes. Hereafter, therefore, the six-key tapping test is referred to whenever reference is made to the motor

coordination test.

Other records secured.--With the use of a hand-dynamometer, records of strength of grip were taken. In addition, chronological age, at the time of first testing, and intelligence quotients were determined.

RELIABILITY OF THE TESTS AND THEIR INTERRELATIONSHIP

Tests were administered, according to the techniques described, to a group of 47 children, all ambulatory cases, ranging in age from 57 to 187 months. This age range makes an unsatisfactory setting for this type of experimental study, but the investigation necessarily had to be carried on in the situation which prevails at the Country Home.

Figures 1, 2, and 3 are distribution curves of the scores on the initial tests of rhythm, motor coordination, and strength, respectively, and indicate that all three tests do differentiate between individuals.

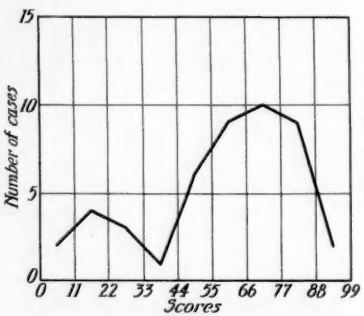

Figure 1. Distribution of scores on rhythm test.

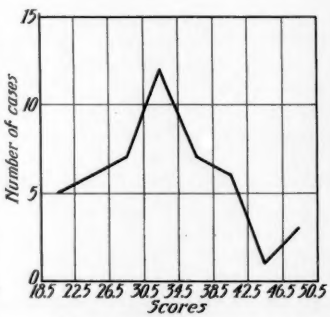

Figure 2. Distribution of scores on motor coordination test.

In order to establish the reliability of the tests, retests were administered within two weeks time. Table I gives the reliability coefficients, with their probable error values, showing high reliability in all cases.

In order to determine the relationship between these several tests and also their respective relationships with chronological age and intelligence quotient, intercorrelations were calculated and are shown in Table II.

As was to be expected, a high positive

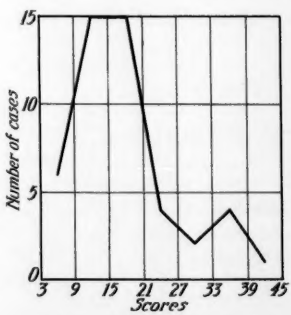

Figure 3. Distribution of scores on strength test.

TABLE I

RELIABILITY COEFFICIENTS

Test	r
Rhythm.....	.91±.02
Motor coordination.....	.91±.02
Strength of grip.....	.96±.008

correlation, many times larger than its probable error, is found between strength and chronological age (.83±.03); an equally high positive correlation between motor coordination and chronological age (.82±.03); and although not quite so high, also a significant positive correlation between rhythm and chronological age (.61 ±.06).

TABLE II

INTERCORRELATIONS OF TESTS

	Rhythm	Motor Coordination	Strength	Chronological Age	IQ
Rhythm	-	.70±.05	.62±.06	.61±.06	.02±.10
Motor Coordination	.70±.05	-	.75±.04	.82±.03	.19±.09
Strength	.62±.06	.75±.04	-	.83±.03	-
Chronological Age	.61±.06	.82±.03	.83±.03	-	-.06±.10
IQ	.02±.10	.19±.09	-	-.06±.10	-

Since there was evidence to indicate some decrease in IQ with increase in age in the group used as subjects for this study, the correlation between chronological age and IQ was calculated and proved to be a small negative quantity (-.06 ±.10), not significant when compared with its probable error.

In order to eliminate this influence of age and determine the true relationship between the several factors under consideration in this study, partial correlations were calculated, holding age constant, with results as shown in Table III.

TABLE III

INTERCORRELATIONS HOLDING AGE CONSTANT

	Rhythm	Motor Coordination	Strength	IQ
Rhythm	-	.44±.08	.26±.09	.07±.09
Motor Coordination	.44±.08	-	.22±.09	.42±.08
Strength	.26±.09	.22±.09	-	-
IQ	.07±.09	.42±.08	-	-

With the age factor eliminated, it will be seen that the correlation between strength and rhythm and between strength and motor coordination drop to figures

that are not significant when compared with their probable errors. The relationship between motor coordination and rhythm, however, remains sufficiently high to be significant (.44±.08), while that between motor coordination and intelligence increases sufficiently to become significant (.42±.08).

It would seem from these figures, therefore, that rhythm (as here tested) and intelligence (as reflected in the intelligence quotient scores) are two components in motor coordination (as tested by the six-key tapping test).

EFFECT OF TRAINING ON RHYTHMIZATION

Comparison of the results of the initial test of rhythm with those of the retest indicates the presence of a large learning element due to the practice effect of the test, itself. (See Figs. 4 and 5 and Table V.)

In order to study the effect of general rhythmic training on rhythmization as tested, two groups of thirteen subjects each, matched as nearly as possible for chronological age, IQ, and rhythmization as indicated on the initial rhythm test, were selected for experimental purposes. One of each matched pair was placed in an experimental group and the other of each matched pair in a control group. These two groups will hereafter be referred to as Experimental Group A and Control Group A'.

Both the experimental and the control groups were then enlarged by adding a few unmatched subjects to each group. The enlarged experimental group, hereafter referred to as Experimental Group B, thus includes the thirteen matched individuals plus five unmatched subjects (total of eighteen subjects), while the enlarged control group, hereafter referred to as Control Group B', includes the thirteen matched individuals plus four unmatched subjects (total of seventeen subjects).

During a period of approximately two months following the retesting, no use, whatever, was made of the tapping mechanism. Throughout this period, the experimental subjects (total group of eighteen children) were given a regular program of rhythmic activities, classes meeting two or three times each week until a total of eighteen class periods had been completed. During this time, the control subjects were left to the usual routine of the Home, taking no part in the rhythm-activities program.

The writer, who has had physical education teaching experience, conducted the rhythm classes, with the assistance of a pianist. Phonograph music supplemented that of the piano on some occasions.

The following activities were included in the rhythm program: tapping, with sticks, rhythm patterns in time with music of both 2/4 and 3/4 time; tapping sticks in unison with rhythm patterns set by the instructor on a tom-tom, the patterning in this situation produced by differences in accent rather than differences in timing; the same types of tapping of rhythm patterns using the foot, in place of sticks held in the hands; beating time with various types of music, using a stick as a baton; a complete rhythm band; marching with and without music; folk dancing; and tap dancing.

Large body activities were impossible for four of the children in the experimental groups, because of their physical disabilities. These individuals used rhythm band instruments (sticks, drums, and bells) to keep time with whatever music was used, throughout the practice periods. Their training was thus of a more specific nature than was that of the remainder of the group.

The order of progression in the rhythmic activities was from small to large muscle-groups, with emphasis on large body activities toward the end of the training period, although the rhythm band was kept in use throughout, as it met with such enthusiasm on the part of the children. The dancing was necessarily limited in scope, since in many cases the physical disability affects the lower extremities. With the exception of the children already mentioned, however, who were unable to take part at all, most of the youngsters made a genuine effort to keep up with the steps of the dance or march even though it was necessary to use some ingenuity where a knee, for example, was restricted by a cast.

At the completion of the training program, a final test of rhythm was administered, according to the described technique, and comparisons made between the experimental and control groups.

TABLE IV

COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS IN SIZE, INTELLIGENCE, AGE, AND STRENGTH

Subjects	Number	IQ		Age in Months		Strength(Grip)	
		Ave.	Range	Ave.	Range	Ave.	Range
Experimental Group A (Matched)	13	88	64-111	108	72-143	14.4	7.0-22.0
Control Group A' (Matched)	13	88	75-104	111	68-136	15.8	11.0-20.5
Experimental Group B (Matched plus unmatched)	18	89	64-111	103	57-143	12.7	4.0-22.0
Control Group B' (Matched plus unmatched)	17	88	66-104	110	68-136	15.8	11.0-20.5

Table IV gives comparisons of the experimental and control groups as to size, intelligence quotient, age, and strength. It will be noted that the control groups show slightly higher average age and average strength scores than do the experimental groups. The difference between Experimental Group B and Control Group B' is greater than that between Experimental Group A and Control Group A', due, no doubt, to the fact that several of the unmatched experimental subjects were in the youngest age classification.

Figures 4 and 5 show graphically the mean rhythm scores of the four groups on the initial test, the retest, and the final test. Several important tendencies are evident from observation of these figures.

In both cases, the control group shows a higher score on the initial test than does the experimental group. This is to be expected, since the average age of the control groups is higher than that of the comparable experimental groups, and a

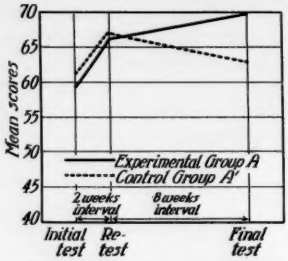

Figure 4. Mean scores on rhythm test for Experimental Group A and Control Group A

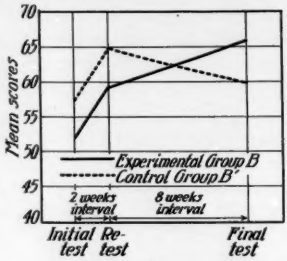

Figure 5. Mean scores on rhythm test for Experimental Group B and Control Group B'

high relationship between rhythm and age has been shown to obtain.

Again, it will be noted that for all groups improvement is shown on the re-test, indicating the presence of practice effects in the performance of the tests.

Finally, the control groups are shown to have dropped back on the final test to approximately the level of their initial performance, whereas the experimental groups show improvement on the final test above that indicated on the retest.

TABLE V

MEAN RHYTHM SCORES ON SUCCESSIVE TESTS

Subject Groups	Initial Test	Retest (After 2 weeks)	Final Test (After 2½ months)
Experimental Group A (Matched)	58.7	66.1	69.5
Control Group A' (Matched)	61.5	67.1	62.9
Experimental Group B (Matched plus unmatched)	52.0	59.1	65.8
Experimental Group B' (Matched plus unmatched)	57.4	64.6	59.8

Analysis of Rhythm test scores.--Table V gives the successive means upon which the curves of Figures 4 and 5 are based. Table VI shows comparisons of these means in terms of percentage change. Table VII gives the differences between the means of the initial and the final tests, with their probable error values.

Since the groups are so small, the probable errors of the differences of the means are very large so that these differences do not satisfy the requirements for statistical significance. It is noteworthy, however, (see Table VII) that for Experimental Group A the difference of the means is more than twice as large as its probable error, and for Experimental Group B the difference of the means is

TABLE VI

COMPARISON OF MEAN RHYTHM SCORES ON SUCCESSIVE TESTS IN TERMS OF PERCENTAGE CHANGE

Subjects	Retest Compared With First Test (14-day interval)	Final Test Compared with Retest (60-day interval)	Final Test Compared with First Test (75-day interval)
Experimental Group A (Matched)	12.6% gain	5.1% gain	18.4% gain
Control Group A' (Matched)	9.1% gain	6.2% loss	2.3% gain
Experimental Group B (Matched plus unmatched)	13.6% gain	11.3% gain	26.5% gain
Control Group B' (Matched plus unmatched)	12.5% gain	7.4% loss	4.2% gain

slightly more than three times its probable error, while for both control groups the probable error of the difference of the means is larger than the difference, itself.

TABLE VII

DIFFERENCES OF THE MEANS OF INITIAL AND FINAL RHYTHM TESTS, EXPERIMENTAL AND CONTROL GROUPS

Subject Group	M - M'
Experimental Group A (Matched)	10.8 ± 4.54
Control Group A' (Matched)	1.4 ± 4.01
Experimental Group B (Matched plus unmatched)	13.8 ± 4.38
Control Group B' (Matched plus unmatched)	2.4 ± 4.20

The difference in performance of the experimental and the control groups on the rhythm test is also noteworthy when shown, as in Table VI, in terms of percentage change from test to test. All four groups improved their mean scores on the retest, above those made on the initial test. However, due to the fact that the experimental groups continued their improvement on the final test while the control groups lost on the final test a good deal of the gain they had made on the retest, the percentage differences between the initial test and the final test are the following: 18.4 per cent gain for Experimental Group A as compared with 2.3 per cent gain for Control Group A'; 26.5 per cent gain for Experimental Group B as compared with 4.2 per cent gain for Control Group B'.

Finally, it seems well to show comparisons of individual records of the subjects making up the several groups. Figures 6 and 7 show the scores made on successive tests by the matched pairs, while Figures 8 and 9 give the individual

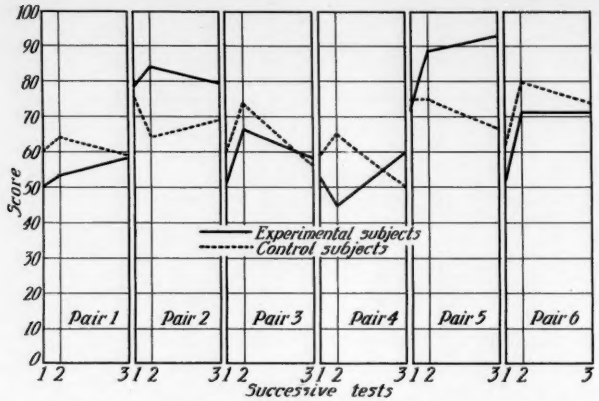

Figure 6. Matched pairs of girls compared for rhythm scores on initial test, retest, and final test.

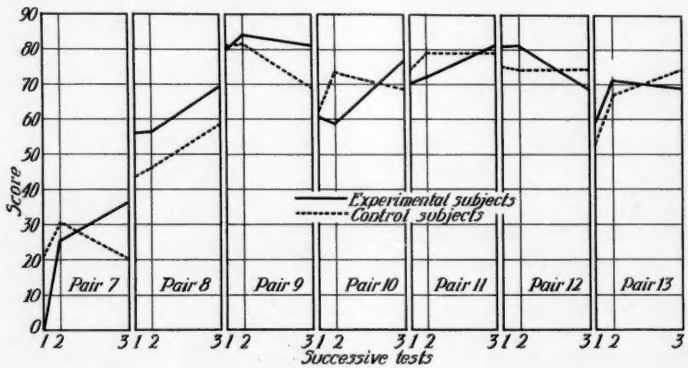

Figure 7. Matched pairs of boys compared for rhythm scores on initial test, retest, and final test.

records of the unmatched subjects.

Examination of Figures 6 and 7 shows that the advantage is with the experimental, or trained, member of the matched pair in ten cases; with the control, or untrained, member of the matched pair in two cases; while one pair shows no advantage for either member.

For the unmatched subjects (Figures 8 and 9), it will be seen that all five members of the experimental group show an upward trend from the retest to the final test, while only one of the four unmatched subjects in the control group shows this trend.

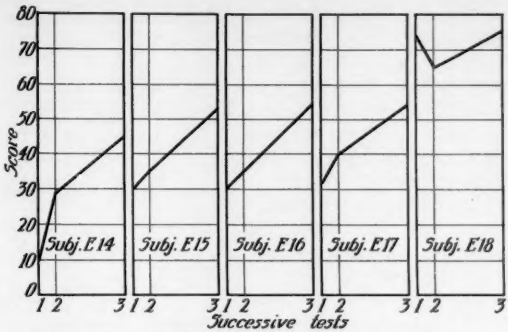

Figure 8. Unmatched experimental subjects - rhythm scores on initial test, retest, and final test.

Upon the consistency of the evidence, then, even though the groups are small and statistical reliability is not established, is based the proposition that rhythm, as tested in this investigation, is improved by general training in rhythmic activities.

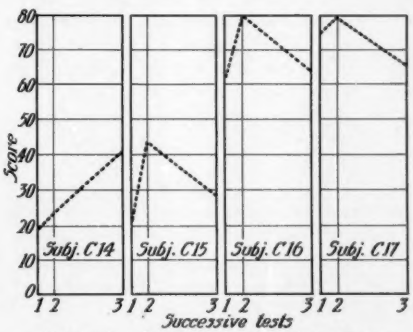

Figure 9. Unmatched control subjects - rhythm scores on initial test, retest, and final test.

Individual difference in rhythmization.--That there are individual differences in rhythmic ability is indicated in the distribution curve of the initial rhythm scores (Figure 1).

Comparison of Figures 1, 2, and 3 reveals differences in the forms of the three curves depicting rhythm, motor coordination, and strength of grip scores, respectively, with the rhythm curve skewed to the left, the motor coordination curve fairly normal and the strength curve skewed to the right. Distribution of the chronological age scores (see Figure 10) produces a curve more similar to that of the motor coordination scores than to either of the other two curves.

Thus, while rhythmization has been shown to be related to age, the difference between the shape of the distribution curve of initial rhythm scores and that of chronological age scores indicates the presence of other differentiation between individuals than that based upon age.

Consideration of a few individual records substantiates this conclusion. Two interesting cases among the younger children are Subjects E17 and E18, whose scores are shown in Figure 8.

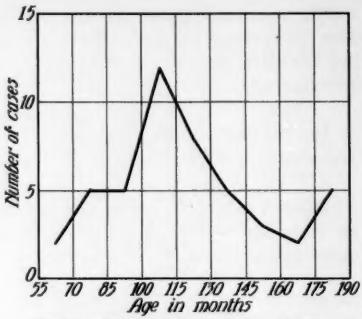

Figure 10. Distribution of chronological age scores of initial group of 47 children

Subject E17 is the youngest subject used in the study (57 months, or less than five years of age), yet her scores on the rhythm tests are comparable to those of several children a year or more older than she. She was even able to follow the more difficult Pattern III, which proved to be too complex for most of the younger children. Her behavior in the experimental situation was erratic, however. Much coaxing was necessary to persuade her to attempt the test at all, and even when she was giving a most creditable performance she was likely to stop and insist that "it's too hard." Equally distressing was her tendency to alternate hands in the course of a trial (she seemed to have no established hand preference), and finally she discovered considerable amusement in performing the rhythm pattern, without a break in rhythm, on adjacent keys rather than on the same key. These antics interfered with the smoothness of her performance and reduced her scores, since accuracy was an important element in scoring the tests, but they also showed the extent of her talent for rhythmizing. Many of the children could not have maintained the patterning at all, had they alternated hands or changed keys as did this child.

The performance of Subject E18 on the rhythm test (see Figure 8) can be seen to compare favorably with all except the two most skillful of the subjects used in the training study, yet her age was only 74 months, or a little over six years. Her activity in the rhythm class was outstanding among the younger children, and her talent in this field had been noted by her kindergarten teacher.

Subject E14 is an example of unusually poor performance. This child, also a girl, was 9½ years of age at the time of the initial test, and has an IQ of 102, which is in the upper bracket for this group of children; yet her rhythmic ability, although she made great improvement or both the retest and the final test, is on a level with that of the youngest of the children.

Of particular interest from the medical standpoint is the performance of the two spastic subjects in the group. One of these was included in the matched pairs, as her disability is of a minor nature. Her record on the rhythm test is shown in Figure 6, where she is the experimental subject of Pair 4. It will be seen that her performance on the retest was not so good as that on the initial test, but her final performance, after training, showed definite improvement above her initial performance.

Subject E16 is a serious case of spastic paraplegia and it was not expected that she could perform adequately on this test. Her record, as shown in Figure 8, is on a level with that of Subjects E15 and E17, who are several years younger than she (her age was 124 months, or over 10 years, at the time of the initial

test). The significant thing in her case, however, is the fact that she made some improvement on the retest, and great improvement on the final test, after the training classes in which her activity was confined to use of the rhythm band instruments.

The improvement made by these two spastic subjects reinforces the theory that training in rhythmic muscular activity is useful for this disability.

Other interesting cases might be cited, but these suffice to show that, even at early age levels, differences in initial ability to rhythmize were found, as were also differences in response to training.

CONCLUSIONS

With certain qualifications pointed out in the body of this paper, the following conclusions seem justified on the basis of the findings of this study.

1. There are individual differences in ability to rhythmize.
2. Rhythmization and intelligence are both related to motor coordination.
3. Rhythmization is subject to improvement through both specific and general training, no matter what the initial level of ability may be.

RECOMMENDATIONS

In the light of the findings of this study, it would seem that the inclusion of training in rhythmic activities could be an important addition to the educational activities of an institution such as the one in which this investigation was carried out.

Most of the children in this group will have many difficulties to face in their efforts to adjust themselves to the physical and social environment in which they must move after leaving the comparative shelter of the Convalescent Home. To the extent, therefore, to which their motor coordinations can be improved, and their motor activities extended - to that extent will they be less odd in their home environment, and therefore less likely to become maladjusted there.

If ability to rhythmize is subject to improvement through training, and if rhythmization is a component in motor coordination, then much may be said in favor of a carefully planned program of activities beginning at the earliest possible age level, among physically normal as well as among physically handicapped children.

Too much of the physical activity of young children is left to incidental training, on the supposition that children will "naturally" run and skip and play and dance. Later, when high school boys and girls do none of these things, but, instead, are awkward and self-conscious in their motor coordinations, we glibly assign their difficulties to heredity, or, perhaps, to a temperamental idiosyncrasy, when, as a matter of fact, the temperamental traits might as easily be assigned to the motor difficulty as the motor difficulty to the temperament.

For the crippled child, a program of rhythmic activities, more or less similar to the one used during the training period of this study, would have a number of useful by-products in addition to the general objectives of improved motor coordination and enlarged sphere of motor activity.

Increased self-confidence and decreased self-consciousness with regard to the physical disability might well be the outcome for the little girl who finds she can dance a folk-dance, and the larger girl who learns a simple tap-dance when always before she has been told that "she couldn't expect to be able to dance."

Interest in music is inevitably fostered by the activities included in this type of program. Much of the first enthusiasm will favor the popular type of "swing" music, but permanent interest of a broader nature could well be developed from this nucleus.

Finally, the surprising improvement shown by the spastic subjects, particularly the more severe of the two cases, suggests that these activities might be an important addition to the physiotherapy program for spastic cases.

CHANGES IN BODY PROPORTIONS DURING INFANCY AND THE PRESCHOOL YEARS: I. THE THORACIC INDEX

HOWARD V. MEREDITH AND VIRGINIA B. KNOTT[1]

It is the purpose of this paper to report an investigation on the developmental course of the thoracic index during the postnatal period from three months to six years of age. The investigation includes (1) a review of previous research related to the problem, (2) an analysis of thoracic index distributions for successive quarterly or semiannual age intervals, (3) an examination of the relation between the trend for thoracic index and the growth patterns for the components of the index, and (4) some comparative findings for thoracic index and for the reciprocal form of this index.

According to a statement by Davenport (7, p. 3), Fourmentin was probably the first to use the term "thoracic index." Fourmentin, in 1874, defined the term as the percentage relation of the maximum transverse chest diameter to the maximum antero-posterior chest diameter. It is in this form - as the breadth of the thorax in percentage of the depth of the thorax - that the thoracic or chest index has been employed in studies on human embryos and fetuses by Müller (15) and by Schultz (19), and in studies on children of school age by Arsimoles and Du Courneau de Carritz (1) and by Davenport (7). Likewise in the present study, the term thoracic index will be used to symbolize the formula:

$$\frac{\text{Transverse Diameter of Thorax} \times 100}{\text{Antero-Posterior Diameter of Thorax}}$$

LITERATURE

Changes in the breadth-depth relationship of the external thorax during the prenatal and neonatal periods have been studied by Rodes (16), by Schultz (19), and by Scammon and Rucker (17).

Rodes (16) obtained thoracic measurements on four embryos and seven fetuses. The transverse diameter was measured at the widest point of the thorax and the antero-posterior diameter at the level of the xiphoid articulation in the midsagittal plane. The ratio of the latter measurement to the former was calculated for each of the eleven specimens. In reciprocal form, the resulting indices for the four embryos were 55.1 at approximately four weeks, 66.6 at five and one-half weeks, 77.9 at seven weeks, and 105.2 at ten weeks. Comparable indices for the one specimen representing the beginning of the fetal period (twelve weeks) and for one specimen representing the end of the fetal period (ten lunar months) were 109.9 and 113.6, respectively. Rodes' finding that the thorax of the young embryo is exceptionally narrow relative to its depth has been frequently commented upon as harmonizing with the fact that the heart of the embryo is relatively large and has a great antero-posterior diameter while the thoracic skeleton is relatively retarded in development.

[1] From Iowa Child Welfare Research Station, State University of Iowa, Iowa City, Iowa.

Schultz (19) studied a series of 623 human fetuses ranging in age from nine to forty menstrual weeks. The transverse and sagittal diameters of the thorax were measured at the level of the junction of the fourth pair of ribs with the sternum. In general, the thoracic index was found to increase "from an average of 104.6 at 9 weeks of fetal life to 118.4 at 12 weeks" and to remain at approximately the same figure from twelve weeks to the end of the fetal period. It will be noted that Schultz confirms the finding of Rodes that the breadth of the thorax equals about 1.05 times the depth of the thorax in the first half of the third prenatal month.

Scammon and Rucker (17) made a study of the changes in chest form between the close of the fetal period and the twelfth day of postnatal life. Their basic data consisted of transverse and antero-posterior measurements of the thorax taken both at the nipple level and at the level of the tenth ribs. Two series of subjects were used. The one series was fifty "late fetuses and full term still-born children" measured by Dr. L. A. Calkins, while the other was twenty-three living infants measured by the authors at the Minneapolis General Hospital. The latter series was measured fifteen minutes following birth, twelve hours later, on the third postnatal day, and (in part) on the fifth, seventh, tenth, and twelfth days after birth. Reduction of the data to index terms was accomplished "by dividing the antero-posterior diameter of the chest by the transverse diameter and multiplying the quotient by 100." (17, p. 559) At the nipple level, mean indices were obtained of 86.0 for full-term fetuses, 106.0 for living infants of fifteen minutes postnatal age, 102.0 for infants born twelve hours, and 100.5 for infants of five and twelve postnatal days. Taking the reciprocal[2] of each of these numbers (in order to derive indices of the form in which the thoracic index has been defined for purposes of the present investigation), the findings become 116.3, 94.3, 98.0, and 99.5, respectively. These findings indicate that the breadth of the thorax stands at about 116 per cent of thoracic depth at the close of intrauterine life, that with the establishment of respiration (it) becomes greater in depth than in breadth, and that though the thorax becomes relatively flatter between the first and twelfth days of postnatal life its breadth does not equal its depth until sometime following the twelfth day. Scammon and Rucker cite evidence to show that these modifications in thoracic form are correlated with "the order and degree of expansion of the different parts of the lungs." (17, p. 564)

Synthesizing the foregoing research for the prenatal and neonatal periods, it may be stated:

1. That the thoracic index increases during the embryonic period from roughly 55 at four weeks, through 105 at nine or ten weeks, to 118 or less at twelve weeks

2. That the thoracic index remains at about 118 throughout the entire fetal period (While the figure from Scammon and Rucker for the close of the fetal period is around 116, these authors note that if corrected for the differential influence of injection of the fetuses

[2] Throughout this study, the decimal points of mathematical reciprocals are adjusted so as to give reciprocal indices a percentage relation analogous to the percentage relation of the original indices.

on the two chest dimensions this figure becomes somewhat higher.)

3. That the thoracic index decreases from 118 to 94 during the first fifteen minutes following birth

4. That the depth of the thorax exceeds the thoracic breadth during the second month of prenatal life and during at least the first twelve days of postnatal life

The trend of change in the external contour of the thorax during infancy and the preschool years has received but meagre study. Some findings are incorporated in publications by Scammon (18), Hrdlička (9), Gray and Ayres (8), Lucas and Pryor (13), and Weisman (21).

Scammon (18) reported on the thoracic form in the first year of postnatal life. His basic data were transverse and antero-posterior measurement values obtained on 600 normal infants, "25 of each sex for each month," by Dr. L. H. Richdorf. Observations were made both at the tenth rib level and at the level of the nipples. The sexes were not differentiated in analysis. At the level of the nipples, chest depth in percentage of chest width was found to descend from a mean of approximately 90 per cent at one month to 78 per cent at one year. At the level of the tenth ribs the descent was from 90 per cent to 85 per cent. Converted to figures for chest width in percentage of chest depth, the findings at the nipple level indicate a thoracic index trend which rises from 111 per cent at one month after birth to 128 per cent at one year of age. This trend implies that the mean breadth of the thorax exceeds the mean thoracic depth at one month of age and that the thorax becomes relatively broader during the first year of postnatal life.

Hrdlička (9), as a small fraction of an extensive study of white and colored asylum children of school age, obtained the ratio of chest depth to chest width for about thirty white children aged five and six years and twenty colored children aged three to six years. Measurements were taken "at the height of the nipples" with "a pair of accurate aluminum sliding compasses" (Hrdlička compass). "In measuring, the branches of the compass were applied not simply to touch the skin but until they met with a marked resistance of the body." (9, p. 48) Taking the reciprocals of the ratios reported, the thoracic index for the subjects of three years is found to be 126 per cent in the case of a single colored male and 116 per cent for two colored females. Corresponding indices at five years of age are 133 for three colored males, 131 for four colored females, 136 for two white males, and 145 for two white females. Finally, the mean figures for thoracic index at six years are 132 for five colored males, 131 for two colored females, 136 for fifteen white males, and 137 for ten white females.

Gray and Ayres (8) published the results from a major investigation on Growth in Private School Children in 1931. Their monograph includes findings on chest form for children five and six years of age. Transverse chest diameter was measured at the level of the nipples and antero-posterior chest diameter at the same level anteriorly and just below the inferior angles of the scapulae posteriorly. Each diameter was taken with straight arm, sliding calipers and recorded as the median value during quiet breathing. The index calculated was that of antero-

posterior diameter in percentage of transverse diameter. At five years of age mean indices were obtained of 73.0 for forty-one males and 73.8 for twelve females. The mean indices for six years of age were 73.0 for eighty-six males and 75.0 for forty-two females. Translated into means for chest width in percentage of chest depth, these figures show chest width to approximate 136 per cent of chest depth at five years of age for both sexes. At six years of age the male width is 1.37 times depth and the female width 1.33 times depth.

Weisman (21) studied the thoracic contour for roughly 2,000 Minneapolis children aged five and six years. "The children were stripped to the waist, and the diameters of the chest were taken at the nipple line with an ordinary pelvimeter (curved calipers) with a scale graduated in centimeters." (21, p. 503) The measurements were made at some thirty schools in different parts of the city. From each pair of observations, Weisman calculated the ratio of the sagittal diameter of the thorax to the lateral thoracic diameter. Analysis by one-year age distributions gave means at five years of 72.0 per cent for 266 males and 71.0 per cent for 238 females, and at six years of 70.7 per cent for 784 males and 71.7 per cent for 733 females. In reciprocal form these figures become 138.9 and 141.4 for males and, for females, 140.8 and 139.5.

Standards for thirteen external dimensions of the body and six anthropometric indices, derived from measurements on about 6,000 "middle class, American-born, white" children between the ages of six months and sixteen years, were recently published by Lucas and Pryor (13). These standards include means for "antero-posterior thoracic diameter divided by transverse thoracic diameter" at nine months of age and at annual intervals from one and one-half to five and one-half years of age. The children were measured at San Francisco during the years 1930 to 1935. "Measurements of transverse chest were taken from the front with straight-arm calipers at the nipple level, the instrument being parallel to the floor." (13, p. 535) Measurements of antero-posterior diameter were made "with the spreading curved calipers at the junction of the fourth rib with the sternum," the instrument being parallel to the floor. All measurements were "done next to the skin" and all reachings were "made during the middle phase of quiet respiration." The findings reported by these authors, together with the reciprocals of their means, are shown in the following tabulation:

Mean Age		Mean	Reciprocal
Years	Months	Index	
		Males	
	9	80.5	124.2
1	6	81.4	122.9
2	6	80.4	124.4
3	6	80.7	123.9
4	6	79.6	125.6
5	6	80.0	125.0
		Females	
	9	84.1	118.9
1	6	83.1	120.3
2	6	81.2	123.2
3	6	81.2	123.2
4	6	78.1	128.0
5	6	78.3	127.7

It will be noted that these indices indicate a distinctly lower order of relative thoracic breadth than that found at comparable ages by Scammon, Hrdlička, Gray and Ayres, or Weisman.

Summarizing the investigations for the infancy and preschool years, it may be stated:

1. That the thoracic index stands at about 111 at one month of age (Scammon)

2. That the thoracic index increases rapidly between one month and one year of age. According to Scammon the index approximates 128 by the end of the first postnatal year. According to Lucas and Pryor the index for this age is about 124 for males and 119 for females.

3. That the trend of the thoracic index between one and six years of age is not established. The studies of Hrdlička, Gray and Ayres, and Weisman imply a rising trend with an index for six years of 135 to 140. Lucas and Pryor, on the contrary, find no rise in the trend for males and a rise to a markedly lower level in the trend for females. Their study shows the thoracic index for the sixth year to stand at 125 for males and 128 for females.

4. That there is need for additional and more exhaustive study of the developmental trend for the thoracic index throughout the infancy and preschool years

Studies dealing with the form of the thorax in subjects beyond the age of six years have been reported by Davenport (7), Gray and Ayres (8), Hrdlička (9, 10), Lucas and Pryor (13), Rodes (16), and Weisman (21, 22, 23, 24). Only the salient findings from each of these studies will be reviewed. The mean indices given in the reports, where necessary, will be converted to transverse diameter of the thorax in percentage of antero-posterior diameter. With two exceptions, the methods and material upon which each of the reports is based have been described previously. This information will not be repeated.

Davenport (7) studied the trend of the thoracic index during childhood and adolescence for two groups of subjects. One group was from the Orphan Asylum of Brooklyn and the other from the Letchworth Village Development, a New York institution for the feeble-minded. The lateral diameter of the thorax was taken "holding the anthropometer rod at the level of the nipples in front, letting the arms of the rod fall across the widest part of the thorax in the vicinity of the 6th or 7th rib." (7, p. 1-2) The sagittal diameter was measured perpendicularly to the long axis of the vertebral column at the level of the nipples - straight arm calipers being used with younger children and curved arms on the upper section of the anthropometer rod with older children. For the age interval from roughly six to sixteen years, the mean thoracic index was found to fluctuate between 132 and 135 for Brooklyn Asylum females, between 130 and 135 for Brooklyn Asylum males, and between 127 and 130 for Letchworth Village males. Besides these gross findings. Davenport presents mean curves for American "Negro," Nordic. and Mediterranean

children of the Letchworth Village population; illustrates different types of index curves for the individual; and discusses the phylogeny of man's thoracic index. Unfortunately, no mention is made of the number of observations employed in the study, and tabular presentation of the findings is entirely lacking.

In contrast to Davenport's study, the study by Weisman (21) is shown to be based on an adequate sample of over 17,000 Minneapolis school children. For males, the mean thoracic index is here found to increase slowly and steadily from 139 at seven years of age to nearly 148 at seventeen years. For females, the increase during the same age period is from 141 to 147. Weisman (22, 23, 24) subsequently analyzed portions of the data with a view to revealing socio-economic and racial differences for thoracic index. He found (1) that children attending schools in the best districts of Minneapolis had less rounded, relatively broader chests than children attending schools in the poorest districts, and (2) that Minneapolis school children of Scandinavian, German, Russian, and Jewish nationality groups "resembled each other closely" in average contour of the chest.

The mean thoracic indices obtained by Hrdlička (9) for white asylum males rise from 139 at seven years to 147 at seventeen years. This trend closely follows the findings of Weisman for his total male sample. Corresponding means for white asylum females indicate a gradually increasing index from 143 at seven years to 146 at eleven years with marked fluctuations thereafter. On comparing mean indices and mean chest dimensions for white and colored asylum children of like age and sex, Hrdlička found a "somewhat deeper character of the chest in the negro children." (9, p. 49)

Gray and Ayres (8) found a less pronounced rise in the mean curve of thoracic index than that reported by Weisman and by Hrdlička. For males, their index rises slowly from 138 at seven years to 141 at seventeen years. For females there is an increase of only 1 per cent - from 133 at seven years to 134 at seventeen years.

The indices reported by Lucas and Pryor (13) differ markedly from those obtained by other investigators in that they give a highly irregular trend from age to age. The mean male index for the sixth year is approximately 127. From the sixth to the thirteenth years the index fluctuates between 127 and 133. At the fourteenth year it drops to 126, and the following year rises to over 136. In the case of females the mean index increases somewhat erratically from 128 for the sixth year to 144 for the thirteenth year, falls to 126 for the following year, and then rises to 137 for the fifteenth year.

Investigations on the thoracic index in the adult have been made by Rodes (16) and Hrdlička (10). Rodes obtained mean indices of 137 for fifty young white women and 141 for forty-eight young colored women. He concluded that the thorax of colored women is relatively flatter than the thorax of white women.

Hrdlička (10) studied the chest form for over four hundred "Old American" adults, mainly residents of Washington, D. C. The transverse and sagittal measurements were recorded as "the mean between inspiration and expiration" obtained with the "broad-branched calipers" at "the level of the nipples in men and at the

corresponding one of the upper border of the fourth costal cartilages in the women." (10, p. 305) The mean findings for thoracic index were 133 for 175 women and 137 for 246 men. Analysis of the sex difference yielded the following: "In depth the female chest stands to that of the male as 92.3 (to 100), in breadth as 89.4 (to 100)...As the stature relation between the two sexes is as 92.8 to 100....it must be concluded that....(there) is a relative narrowness of the chest in the females." (10, p. 306) Finally, Hrdlička obtained average indices for his twenty-five youngest cases of each sex and his twenty-five oldest cases of each sex. These were 135 and 128 for the women, 141 and 130 for the men. It was concluded: "Remarkable and unexpected differences in the chest appear when our data are analysed as to age. It not only becomes evident that the chest increases in size with age after supposedly full growth has been reached, but also that it increases unevenly. It grows during adult life moderately in breadth, but more markedly in depth, particularly so in the males, thus reversing the conditions during childhood and adolescence. The chest in the young adults is flatter than in those after fifty...." (10, p. 306)

DATA

The original data of the present investigation consist of 2,037 paired measurements for width and depth of the thorax on 557 males and 1,631 paired measurements for like dimensions of the thorax on 448 females. These data were obtained from physical measurement records made at the University of Iowa infant laboratory, preschool laboratories, and elementary school. They represent observations accumulated on Iowa City children during the years 1929 to 1936 by the anthropometric staff of the Iowa Child Welfare Research Station.

Each record was taken from the files in serial order and accepted for tabulation provided (1) that it fell between the age limits of one and one-half months and six years, two months, thirty days, (2) that it carried paired values for transverse and antero-posterior diameters of the thorax taken at the level of the ensiform or xiphoid cartilage, and (3) that it was not marked as applying either to an individual of Negroid, Mongoloid, Jewish, or southwest European stock, or to an individual considered to lie outside the normal zone for physical build.

Detailed information on country of birth of the parents and grandparents and on the occupation of the father was available for approximately 50 per cent of the subjects. Analysis of this material yielded the following findings:

1. Both parents for approximately 92 per cent of the subjects were born in the United States.

2. For around 55 per cent of the subjects, the parents and four grandparents were all born in the United States.

3. Roughly 31 per cent of the fathers were professional people and an additional 24 per cent were business proprietors, managers, or salesmen. Four per cent only were day laborers, and the remaining 41 per cent were about evenly divided between skilled trade employees, clerks and carriers, and students.

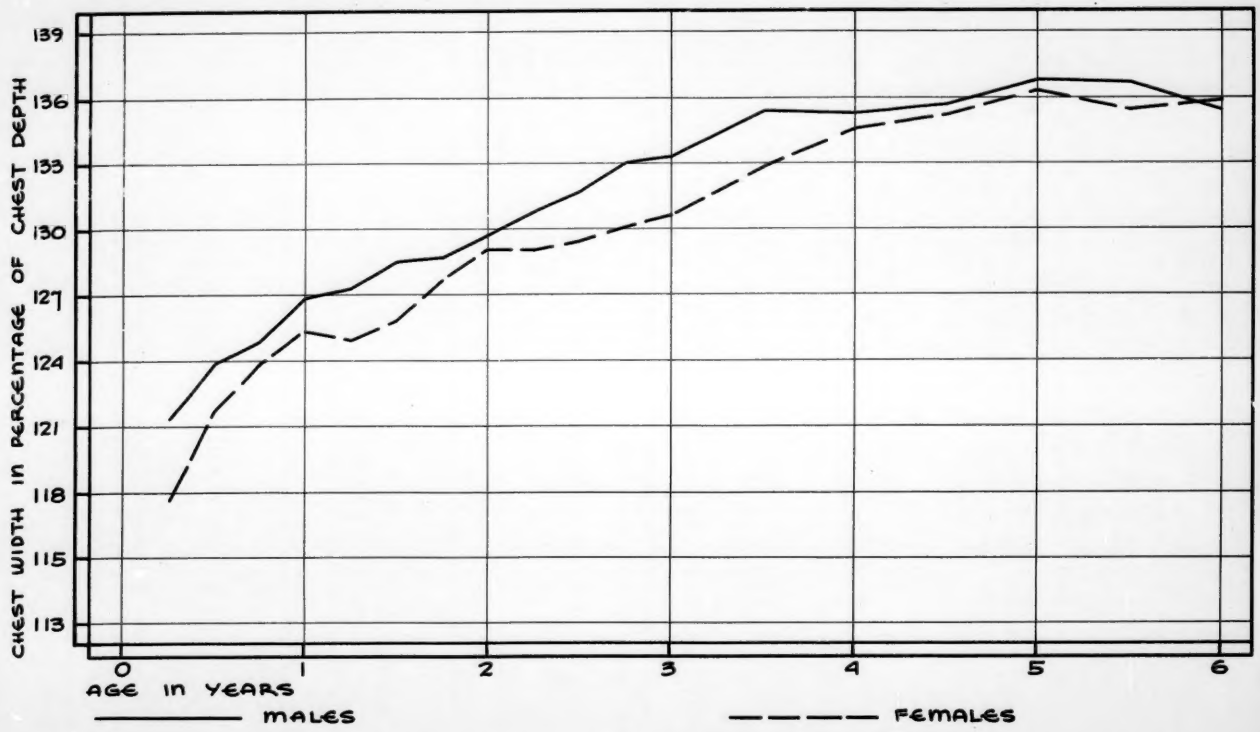

Figure 1. Thoracic Index Curves: Drawn to Mean Values Given in Table 1.

The sample as a whole may be summarily characterized as being homogeneous with respect to geographic location, consisting of American-born children of northwest European ancestry, and representing a population that is heavily weighted with the professional and managerial classes.

As indicated in the introduction of this paper, the thoracic index is:

$$\frac{\text{Transverse Diameter of Thorax} \times 100}{\text{Antero-Posterior Diameter of Thorax}}$$

With reference to our original data, this formula was applied to transverse and antero-posterior measurements made at the level of the xiphisternal junction wit the large, straight arm, sliding calipers (Hrdlička compass).

THE THORACIC INDEX

Thoracic index values were computed from each pair of thoracic measurements. These derived values were then grouped into thirty-six distributions, eighteen for males and eighteen for females. In the case of each sex, eleven distributions covered the successive quarter-year intervals from one month, fifteen days to two years, ten months, fourteen days while the remaining seven distributions covered the consecutive half-year intervals from two years, nine months to six years, two months, thirty days. The results from analysis of these distributions are given in Table 1. Figure 1 shows curves of thoracic index drawn to the mean indices for males and females. Inspection of this table and graph yields the following findings:

1. There is an increase in mean thoracic index for both sexes during the age period from three months to five years. The increase is from 121.4 to 136.8 for males and from 117.7 to 136.4 for females. It follows, then, that the transverse diameter of the thorax is found to be relatively broader at five years of age than at the age of three months by 15.4 per cent and 18.7 per cent for males and females, respectively.

2. The increase in mean thoracic index is greater between three months of age and two years of age than during any similar age interval which follows. Relative to its antero-posterior diameter, the thorax of males is 8.3 per cent broader at two years than at three months and only 5.5 per cent broader at four years than at two years. The corresponding percentages for relative broadening in females are 11.3 and 5.6. Within this period of rapid increase, greater gain is made between three months and one year of age than during the second year.

3. During the sixth year both males and females show a minor decrease in mean thoracic index. The mean indices obtained for the end of the sixth year are 135.5 for males and 135.9 for females.

4. Males exceed females in mean thoracic index throughout the entire age period studied except at six years. From three months to four years of age the male means are markedly higher than the female means, from four to five and one-half years the differences are less pronounced, and at six years the female mean is

TABLE 1

THORACIC INDEX: TRANSVERSE DIAMETER OF THORAX AT LEVEL OF XIPHOID CARTILAGE IN PERCENTAGE OF ANTERO-POSTERIOR DIAMETER OF THORAX AT SAME LEVEL*

Mean Age		Cases	Mean	Standard Error of Mean	Standard Deviation	Range
Year	Month					
Males						
	3	65	121.4	1.15	9.30	106 to 145
	6	109	123.9	.80	8.37	106 to 145
	9	136	124.8	.74	8.59	101 to 153
1	0	152	126.9	.72	8.82	106 to 146
1	3	141	127.2	.80	9.46	103 to 154
1	6	118	128.5	.74	8.04	110 to 149
1	9	103	128.7	.82	8.37	111 to 153
2	0	109	129.7	.83	8.70	114 to 150
2	3	101	130.8	.82	8.25	113 to 155
2	6	94	131.8	.90	8.73	115 to 152
2	9	97	133.0	.87	8.54	114 to 150
3	0	122	133.3	.72	7.91	114 to 151
3	6	119	135.4	.67	7.35	113 to 153
4	0	113	135.2	.77	8.21	115 to 154
4	6	109	135.7	.79	8.23	113 to 159
5	0	116	136.8	.82	8.80	112 to 160
5	6	122	136.7	.75	8.25	116 to 162
6	0	111	135.5	.81	8.59	113 to 161
Females						
	3	51	117.7	1.13	8.10	103 to 137
	6	106	121.7	.75	7.69	104 to 137
	9	117	123.9	.66	7.14	109 to 141
1	0	119	125.3	.67	7.34	110 to 143
1	3	108	125.0	.56	5.87	111 to 140
1	6	98	125.8	.64	6.38	113 to 142
1	9	87	127.6	.81	7.58	110 to 144
2	0	74	129.0	.78	6.69	111 to 143
2	3	81	129.0	.82	7.35	111 to 147
2	6	71	129.4	.76	6.43	114 to 145
2	9	70	130.1	.87	7.28	111 to 146
3	0	71	130.7	.91	7.68	113 to 147
3	6	83	132.9	.68	6.17	120 to 148
4	0	87	134.6	.78	7.26	118 to 150
4	6	97	135.2	.73	7.18	118 to 151
5	0	109	136.4	.67	6.97	120 to 153
5	6	104	135.5	.66	6.75	121 to 151
6	0	98	135.9	.70	6.89	119 to 155

* The basic data are measurement values for Iowa City males and females of northwest European descent.

slightly higher than the male mean. It is thus found that the male thorax is relatively broader than the female thorax below four years of age, but that sex differences become minimized from four to six years of age.

5. Variability in thoracic index, as measured by the standard deviation, shows no consistent trend either toward increase or decrease during the period from six months to six years. Though age differences are negligible, however, there is a systematic sex difference such that the average of the standard deviations between six months and six years is 8.4 for males and 7.0 for females. A zone of one standard deviation above and below the means for two years of age would thus include all male indices from 121.3 to 139.1 and all female indices with the limits of 122.0 to 136.0.

6. There is almost complete overlapping of the distributions for a given sex at successive ages. This may be illustrated by comparative findings obtained on use of the extreme distributions for males as points of reference. It will be noted that the range for males at three months of age is from 106 to 145. The upper limit of this range is exceeded by only 4.6 per cent of the cases at two years and by only 12.6 per cent of the cases at six years. Conversely, the range at the age of six years is from 113 to 161. No case falls below the lower limit of this range at two years, and only 20 per cent of the cases at three months have an index lower than 113.

THE COMPONENTS OF THORACIC INDEX

In the previous section it was shown that mean thoracic index increases during the period extending from three months of age to at least five years of age. This increasing index was interpreted as indicating that the transverse diameter of the thorax gradually becomes broader in relation to the sagittal diameter. No attempt was made, however, to elucidate the growth patterns which merge to give the rising index at their composite resultant. Obviously, the rising index - and the relative thoracic broadening which it implies - may be due (1) to increase of chest width in the absence of increase in chest depth, (2) to absence of increase in chest width with a decrease in chest depth, (3) to more rapid rate of increase in chest width than in chest depth, or (4) to some combination or these relationships.

It is the purpose of this section to make a separate analysis for each component of the thoracic index and thereby to reveal the growth relationships which are compounded in the trend of the index during infancy and the preschool years.

Findings obtained from statistical reduction of our male[3] data for width and depth of the thorax are given in Table 2. This table shows:

1. The mean transverse diameter of the thorax increases from 13.25 cm. at the age of three months to 18.75 cm. at six years of age. This is an increase of 5.5 cm. or 41.5 per cent of mean size at three months. According to Boynton (5, p. 22), the increase for females is 5.7 cm. or 45.8 per cent, the mean at three months being 12.45 cm. and at six years 18.15 cm.

2. There is an increase in mean antero-posterior diameter of the thorax from 10.95 cm. at age three months to 13.87 cm. at age six years. With reference to the mean at three months, this increase amounts to 2.92 cm. or 26.7 per cent. Boynton's means for females are 10.46 at three months and 13.15 at six years (5, p.23). The female increase on mean size at three months is thus shown to be 2.69 cm. or 25.7 per cent.

3. Between two and three years of age the antero-posterior diameter of the thorax remains almost stationary in mean size. The mean at two years is 12.95 cm. and at three years 13.05 cm., the difference being one-tenth of a centimeter. Comparable means for females, from Boynton, are 12.43 and 12.46, respectively.

[3] A similar analysis of female data for each of these thoracic dimensions has been previously reported by Boynton (5).

TABLE 2

THORACIC DIMENSIONS (CENTIMETERS); MEAN, STANDARD ERROR OF MEAN, STANDARD DEVIATION, AND RANGE VALUES*

Mean Age Year	Mean Age Month	Cases	Mean	Standard Error of Mean	Standard Deviation	Range
		Transverse Diameter				
	3	65	13.25	.13	1.05	11.3 to 15.6
	6	109	14.44	.08	.83	11.9 to 16.3
	9	136	14.96	.07	.82	12.9 to 16.6
1	0	152	15.59	.06	.76	14.0 to 18.0
1	3	141	15.96	.07	.85	13.9 to 18.4
1	6	118	16.25	.07	.78	14.2 to 18.6
1	9	103	16.48	.07	.74	14.7 to 18.3
2	0	109	16.73	.07	.75	14.8 to 19.0
2	3	101	16.87	.08	.76	15.0 to 19.2
2	6	94	17.07	.09	.87	15.2 to 19.2
2	9	97	17.21	.09	.92	15.0 to 19.6
3	0	122	17.36	.08	.88	15.2 to 19.4
3	6	119	17.60	.08	.83	15.5 to 19.5
4	0	113	17.92	.08	.90	15.8 to 20.4
4	6	109	18.10	.08	.82	16.2 to 20.1
5	0	116	18.36	.08	.88	16.4 to 20.6
5	6	122	18.53	.08	.95	16.5 to 21.0
6	0	111	18.75	.11	1.12	16.4 to 21.5
		Antero-Posterior Diameter				
	3	65	10.95	.10	.79	9.4 to 12.4
	6	109	11.68	.06	.67	10.0 to 13.2
	9	136	12.03	.07	.85	10.1 to 14.2
1	0	152	12.33	.07	.92	10.2 to 15.2
1	3	141	12.59	.08	.94	10.8 to 15.0
1	6	118	12.68	.08	.82	11.0 to 15.1
1	9	103	12.84	.08	.84	10.9 to 15.0
2	0	109	12.95	.09	.91	10.9 to 15.1
2	3	101	12.94	.08	.85	10.9 to 14.8
2	6	94	12.99	.09	.90	11.2 to 15.0
2	9	97	12.97	.09	.84	10.9 to 14.9
3	0	122	13.05	.08	.83	10.9 to 15.3
3	6	119	13.03	.07	.73	11.3 to 15.2
4	0	113	13.28	.07	.76	11.2 to 14.9
4	6	109	13.37	.08	.79	11.7 to 15.0
5	0	116	13.48	.08	.83	11.8 to 15.6
5	6	122	13.58	.07	.81	11.5 to 15.4
6	0	111	13.87	.09	.90	11.6 to 15.6

* Basic data are transverse and antero-posterior measurements at the xiphoid level for Iowa City white males.

It follows from these findings that the rising thoracic index between three months and five years of age is due, in the main, to increase in transverse diameter in the absence of increase in sagittal diameter during the third year and to more rapid rate of increase in transverse diameter than in sagittal diameter during the age spans before and following the third year.

CHANGES IN THORACIC INDEX IN RELATION TO RATES OF GROWTH FOR THE COMPONENTS OF THORACIC INDEX

A more detailed study of the relation between the growth patterns for each of the components of the thoracic index and the age trend for the index itself may be made by the use of Figure 2 in conjunction with Figure 1.

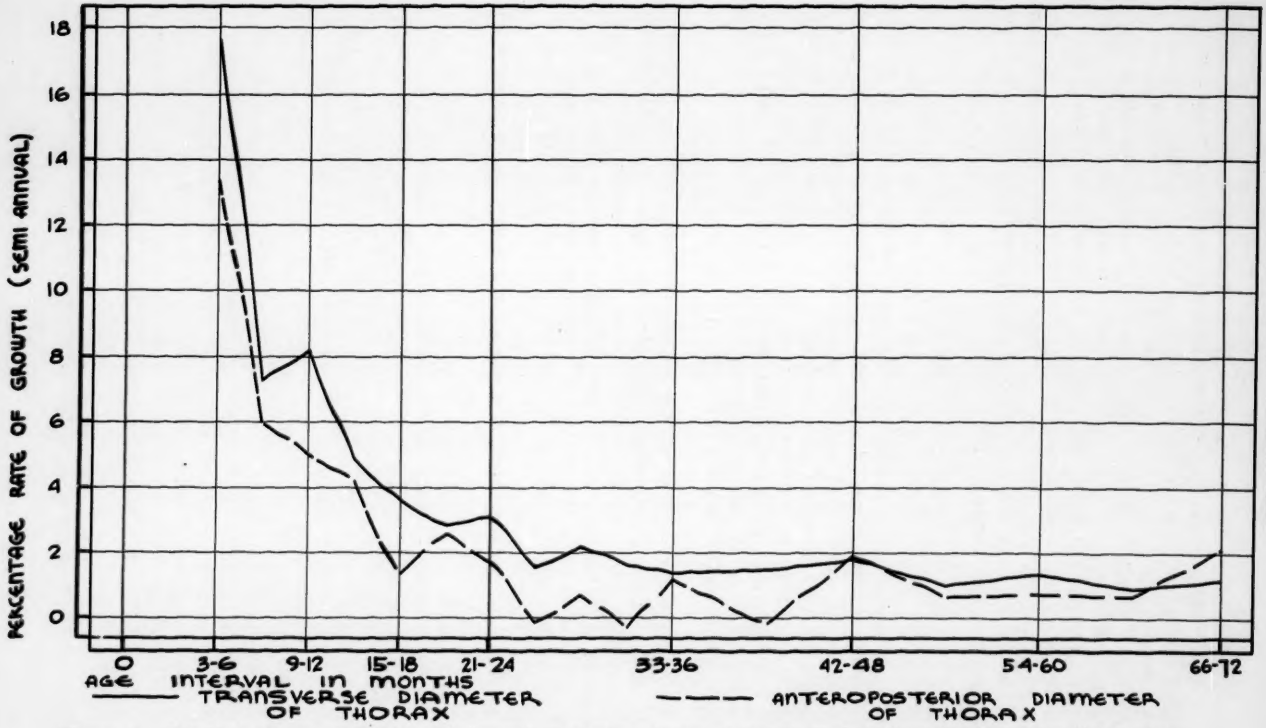

Figure 2. Relative Increment Curves: Semiannual Percentage Rates of Growth Derived from the Means for Males Given in Table 2.

Figure 2 gives the percentage increment curves, in semiannual terms, for width and depth of the male thorax. The percentage rate values to which these curves are plotted were derived from the series of means in Table 2 by use of Minot's arithmetic formula. This formula requires, for example, that in order to find the percentage increment in thoracic width between five and one-half and six years of age, one obtains the difference between 18.53 and 18.75 (Table 2) and divides this difference by 18.53. The result is an increment for the half-year interval of 1.2 per cent. Below three years of age the percentage rates were obtained for quarterly intervals and then multiplied by two to convert them to semiannual terms. With all increment values thus expressed in like form, it was possible to plot them on a single graph.

Figure 2 shows:

1. The percentage rate of growth for antero-posterior diameter of the thorax only exceeds the percentage rate of growth for transverse diameter for the two age intervals three and one-half to four years and five and one-half to six years. Reference to the curve for males in Figure 1 yields the parallel finding that at four and six years respectively there are reversals or setbacks in the rising trend of thoracic index. While in the earlier instance the relative broadening of the thorax is negligible, at the later age the decrease in index is from 136.7 at five and one-half years to 135.5 at six years.

2. The percentage rates of growth for transverse and antero-posterior diameters of the thorax closely approximate each other for the age intervals one and one-half to one and three-fourths years and two and three-fourths to three years. The semiannual rates for the former interval of 2.8 per cent in chest width and 2.6 per cent in chest depth are paralleled by an exceptionally slight rise in thoracic index from 128.5 at one and one-half years to 128.7 at one and three-fourths years. For the latter interval, the semiannual rates of increment of 1.4 per cent and 1.2 per cent are likewise paralleled by a minor rise in thoracic index from 133.0 at two and three-fourths years to 133.3 at three years.

3. The age intervals at which the transverse and antero-posterior percentage rate curves diverge most widely from each other are the age intervals at which the thoracic index rises most abruptly. From three to six months of age, for instance, the semiannual increase rate is approximately 4.5 per cent higher for chest width than for chest depth, and the thoracic index increases from 121.4 to 123.9.

In reporting these findings it is not the intention of the authors to imply that either the irregularities in the rising curves of Figure 1 or the fluctuations in the descending curves of Figure 2 are biologically significant. The objective in this section has been to illustrate, by means of the particular sample under study, the synchronous relationship between changes in thoracic index and percentage rates of growth for the two components of the index.

MEAN THORACIC INDEX COMPARED WITH THE RATIO OF MEAN CHEST BREADTH TO MEAN CHEST DEPTH

Several investigators, concerned with the study of growth in bodily dimensions

rather than with age changes in bodily proportions, have published means for both the transverse and the antero-posterior diameter of the thorax at various ages during the infant and preschool years. American studies reporting such means are those by Baldwin and Stecher (2), Baldwin, Fillmore, and Hadley (3), Bayley and Davis (4), Boynton (5), Crum (6), Iowa Child Welfare Research Station (11, 12), Meredith (14), and Schwartz, Britten, and Thompson (20). Given a knowledge of the relationship between mean thoracic index and the ratio of mean transverse diameter to mean antero-posterior diameter, the paired series of means from each of these studies could be used for comparative purposes by those interested in the thoracic index during the infancy and preschool period.

Table 3 presents, for the male data employed in this paper, a comparison of mean thoracic index and the ratio of mean chest width to mean chest depth. The column of this table headed "Index Minus Ratio" shows that during the age period from three months to six years the mean thoracic index is consistently higher by .2 to .5 per cent than the ratio of mean thoracic width to mean thoracic depth. It may be concluded, therefore, that for the age interval covered by this study (1) there is a systematic difference between mean thoracic index and the quotient for chest width divided by chest depth, but (2) this difference is sufficiently small so that in comparing the findings by the one method on one sample and by the other method on another sample it may usually be disregarded.

TABLE 3

MEAN THORACIC INDEX COMPARED WITH RATIO FOR MEAN CHEST WIDTH IN PERCENTAGE OF MEAN CHEST DEPTH (MALE DATA)

Mean Age		Cases	Thoracic Index	Ratio of Thoracic Means	Index Minus Ratio
Year	Month				
	3	65	121.4	121.0	.4
	6	109	123.9	123.6	.3
	9	136	124.8	124.4	.4
1	0	152	126.9	126.4	.5
1	3	141	127.2	126.8	.4
1	6	118	128.5	128.2	.3
1	9	103	128.7	128.3	.4
2	0	109	129.7	129.2	.5
2	3	101	130.8	130.4	.4
2	6	94	131.8	131.4	.4
2	9	97	133.0	132.7	.3
3	0	122	133.3	133.0	.3
3	6	119	135.4	135.1	.3
4	0	113	135.2	134.9	.3
4	6	109	135.7	135.4	.3
5	0	116	136.8	136.3	.5
5	6	122	136.7	136.5	.2
6	0	111	135.5	135.2	.3

THE RECIPROCAL OF THORACIC INDEX

Many investigators and clinicians are accustomed to expressing the relationship between thoracic breadth and thoracic depth in terms of the ratio of the latter to the former. For the convenience of these workers it was decided to compute indices of the form

$$\frac{\text{Antero-Posterior Diameter of Thorax} \times 100}{\text{Transverse Diameter of Thorax}}$$

for each of the 3,668 pairs of measurements included in the original data of this study. As in the case of the thoracic index values, these values for the reciprocal of thoracic index were grouped into thirty-six distributions (eighteen for each sex) and the mean of each distribution obtained. The results are given in Table 4.

TABLE 4

RECIPROCAL OF THORACIC INDEX: MEAN PER CENTS FOR IOWA CITY MALES AND FEMALES OF NORTHWEST EUROPEAN DESCENT

Mean Age		Males		Females	
Year	Month	Cases	Mean	Cases	Mean
	3	65	82.9	51	85.3
	6	109	81.0	106	82.5
	9	136	80.4	117	80.9
1	0	152	79.2	119	80.1
1	3	141	79.0	108	80.2
1	6	118	78.1	98	79.7
1	9	103	78.0	87	78.6
2	0	109	77.5	74	77.7
2	3	101	76.5	81	77.8
2	6	94	76.2	71	77.5
2	9	97	75.5	70	77.0
3	0	122	75.2	71	76.8
3	6	119	74.1	83	75.4
4	0	113	74.3	87	74.5
4	6	109	74.0	97	74.2
5	0	116	73.4	109	73.5
5	6	122	73.4	104	74.0
6	0	111	74.1	98	73.8

The means in Table 4 are not, of course, identical with the reciprocals of the means in Table 1. However, the differences are found to be small and to be consistently in the direction of the former being larger than the latter. In this connection it appears pertinent to call attention to the fact that, for the data under analysis, the reciprocals of means and the ratios of one mean to another are always smaller than mean indices derived directly from index numbers for each pair of measurements. That is, the ratio of $\frac{\text{Mean Chest Width}}{\text{Mean Chest Depth}}$ is less than the mean of $\frac{\text{Width}}{\text{Depth}}$, the ratio of $\frac{\text{Mean Chest Depth}}{\text{Mean Chest Width}}$ is less than the mean of $\frac{\text{Depth}}{\text{Width}}$, the reciprocal of mean of $\frac{\text{Width}}{\text{Depth}}$ is less than the mean of $\frac{\text{Depth}}{\text{Width}}$, the reciprocal of mean of $\frac{\text{Depth}}{\text{Width}}$ is less than the mean of $\frac{\text{Width}}{\text{Depth}}$. In no case is the difference greater than

.8 per cent, while the average difference approximates .4 per cent. (See, for example, Table 3).

SUMMARY

The major portion of this study is concerned with an analysis of thoracic index values for males and females in the infancy and preschool age periods. These values are computed as the percentage relation of chest breadth to chest depth and are derived from around 3,500 paired thoracic measurements taken on approximately 1,000 Iowa City children of northwest European ancestry.

Secondary consideration is given to the concomitant variations in the growth rates for the transverse and antero-posterior dimensions of the thorax. Means for the reciprocal of thoracic index are also presented.

A review is made of the research literature on the thoracic index. This includes findings with reference to the developmental trend for the index not only throughout infancy and the preschool years but also during prenatal life and between childhood and adulthood.

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TEACHING THE PRESCHOOL CHILD TO REASON

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The desire of the child to understand the cause of what he sees as effects or results is brought out in the numerous questions he asks, such as "How does green grass make white milk? Why doesn't my stomach have teeth? Will tomorrow be yesterday some time? Is bones the lattice work on my body? Where was I before I was borned? Is there rubber in my spine so I can bend down and pick up my things? Why does God put on the darkness at night? Is it because Joe ate pickles that he's cross at me?" These, and hundreds of other questions, indicate the desire to get at the causes back of effects. This phase of the child's thinking should be encouraged. It will solve many behavior problems. For example, when Bobby ran against the table, bumped his head, and began to pummel the table, it was appropriate to question him thus: "Was it the table that made you bump your head? Were you running through the room not looking where you were going?" After a moment's thought, he drew his own conclusions: "Why, mother, I bumped my own head--the table didn't bump me--I bumped the table. I do not want to bump my head. If I look where I am going I will not bump my head any more."

Bobby had just been given boards, a hammer, and nails, and told he might make himself some playthings. His mother was weeding the garden. He asked: "Mother, are you helping the plants to make themselves?" "Yes, Bobby, I'm helping the flowers to grow, but just what do you mean by helping the plants to make themselves?" The pre-school child was silent a moment, and then he answered: "Well, you're helping the plants like God helps the alligator pear tree to make itself. God puts the sun out to shine, and tells the clouds to let down the rain, and says to the tree, 'Now you got things to make things out of, so you make your own leaves and your own pears out of the sunshine I give you, and the water, and the fresh air, and the dirt.'"

Just so, the child indicates that he is beginning to grasp the idea of process or of continuity, without which he could never really comprehend life. Into this constructive view of life the little child may be led as naturally and as healthfully as into the realization that he breathes, or that he has brothers and sisters. Education should help him to see in the effect a cause; or in other words, he is to be taught to become a rational being.

The mother or teacher can give the preschool child much more logical training than is often done. A beginning of this type of training was made with the four-year old son of the writer, who is a teacher and a mother. Bobby demonstrated his ability to analyze a situation and to make reasonable adaptations when his mother was detained one day at school past the noon hour. He knew that there was little in the house to eat, but that mother intended to return with food for lunch. He also understood that he could take any of his problems to the next door neighbor whenever he wished to do so. But he chose to act independently. No mother, no lunch was sufficient motivation for action. He quickly climbed the alligator pear

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tree in the back yard, plucked two huge pears, went down to the street corner, stood a few moments advertising a sale on alligator pears--two for a dime--presently sold them, then with the money thus obtained purchased, at the corner grocery store, a pint of milk and a small loaf of bread. Returning home he set the table and was happily eating his lunch when mother arrived upon the scene. "I thought you had to stay at school and help some of those children of yours," he remarked, unconcernedly, "so I just made my own dinner. You always told me to use my head. I used my feet too. I knew you didn't care if I climbed the tree and got a couple of pears, 'cause there's lots of baby pears growing bigger every day."

As far as consistent with his well-being the child should live in a real world of problems similar to the situations he will later encounter where he will need to figure out things for himself, stand upon his own decisions, and fight his own battles. He should be able to see in human relationships the causes of such results as unfriendliness, selfishness, inequality; to have special training in the art of living.

The tracing of faults in children back to their causes helps much in rooting them out. As an example of this, the writer's little daughter, whom we will call Betty, came crying to the house one day looking for sympathy. She had quarreled with her next door neighbor, Annie. "Annie won't play with me any more, mother. I haven't anybody to play with," she sobbed. Then mother asked the following questions: "Can you just think a moment what caused her to leave you? Were you kind and generous to her?" Betty hung her head, as she replied, "I wouldn't let her play with the new dress I made my doll, and I didn't want her to put my dollie to sleep all the time. Annie started to cry and I said 'If you're going to be a cry baby, well you can go back to your own yard, 'cause our flowers won't grow well in salt tears you're shedding all around here.'" "Well, what do you think you can do to make Annie happy again?" she was asked. Betty's face brightened, "I could make her a doll dress for her very own like the one I have, and I could let her play with my sleepy doll, and we could play in my doll-house. Do you think that would make her happy?" she asked. "You might try", it was suggested. The plan worked out well, for Betty had learned something about analyzing a situation to find the cause of an unpleasant effect, and then she had set about starting a cause that would give the desired effect.

One little preschool child was able not only to trace back physical aches, but irritated moods to disordered stomach aches. "Do you suppose, mother, that why Tommie was so cross to all the children today was because he had eaten lots of vinegar or pickles or pepper?" he asked.

The child who has been taught to understand causes and effects sees readily that his discomfiture or his disgrace is merely the natural consequence of his deed, and he usually accepts it without rebellion or a revengeful thought. It is Nature's way of teaching the child who puts out his hand and touches a hot radiator. No whirlwind of force rushes forward and whisks him away from the natural consequence of being burned. Bobby's brother, whom we will call Billy, may be used in way of illustration. When he asked to be allowed, for a week, to manage the wearing of his supply of clean blouses, he was reminded that on Friday a little

neighbor boy had invited him to a birthday party, and that it would be necessary for him to save a clean blouse for the occasion if he were to attend the party. He agreed to do this, but in his excitement and lack of forethought soiled all his blouses before the fateful day arrived. He was quite surprised to find all his available wearing apparel unfit for a public appearance. He attempted to make other adjustments, but none was satisfactory; so he resigned himself to remaining peacefully at home as the natural consequence of his own deeds. Sitting apart in thoughtful mood, this five-year-old was overheard saying to himself: "After all, policemens are good, mothers are good, and God is good." He had himself arrived at this conclusion, and had ventured a generalization.

Not alone is the little child affected by having the connection of cause and effect shown him, but unthinking adults, those children of larger growth, also feel the effects. The parent who is guided by this principle has an excellent opportunity for observation of the growth of the child in thinking. The shortened and discontinuous school period may not offer as rapid growth, yet teachers who attempt guidance based upon this principle would observe development in rational self-determination.